Instruction Manual

ES-FLOW™ 1xxC

Ultrasonic Liquid Flow Meter/Controller

Doc. no.: 9.17.153 rev. A Date: 24-06-2021

ATTENTION
Please read this document carefully before installing and operating the product.
Not following the guidelines could result in personal injury and/or damage to the equipment.

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Symbols on the equipment

One or more of the following signs may be attached to the product:

Read the instruction manual before installing and operating the product

General warning; consult the instruction manual for handling instructions (the appearance of this symbol may vary)

Surface may get hot during operation

Shock hazard; electrical parts inside

Symbols in this document

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

Tips, useful information, attention points. This will facilitate the use of the instrument and/or contribute to its optimal performance.

Additional information available in the referenced documentation, on the indicated website(s) or from your Bronkhorst representative.

Warranty

Bronkhorst® products are warranted against defects in material and workmanship, provided they are used in accordance with the ordering specifications and not subject to abuse or physical damage. Products that do not operate properly during the warranty period may be repaired or replaced at no charge.

The warranty includes all initial and latent defects, random failures, and indeterminable internal causes. It excludes failures and damage caused by the customer, such as contamination, improper electrical hook-up, physical shock, etc.

Re-conditioning of products primarily returned for warranty service that is partly or wholly judged non-warranty may be charged for.

Bronkhorst High-Tech B.V. or affiliated company prepays outgoing freight charges when any part of the service is performed under warranty, unless otherwise agreed upon beforehand. However, if the product has been returned collect to our factory or service center, these costs are added to the repair invoice. Import and/or export charges, foreign shipping methods/carriers are paid by the customer.

Receipt of equipment

- Check that the outer packaging and its contents have not been damaged during transport. If the outer packaging or its contents are damaged, the local carrier must be informed immediately regarding his liability, if so required. At the same time a report should be submitted to your Bronkhorst representative.
- Check the packing list to ensure that you received all items included in the scope of delivery.
- Do not discard spare or replacement parts.
- See Removal and return instructions for information about return shipment procedures.

Equipment storage

- The equipment should be stored in its original package in a climate controlled storage location.
- Care should be taken not to subject the equipment to excessive temperatures or humidity.
- See technical specifications for information about required storage conditions.

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1 Introduction

1.1 Scope of this document

The **ES-FLOW™ 1xxC** is a precise and compact volume flow meter/controller for liquids, based on a novel ultrasonic technology. A wide range of liquids can be measured independent of fluid density, temperature and viscosity.

Measuring is done in a straight tube, where multiple transducers measure both the surface acoustic wave and the transit time through the media. All upstream and downstream combinations are recorded and processed in nanoseconds. The sound wave velocity and the surface area are recalculated to the volume flow rate. This ultrasonic measuring method is fast, accurate and inherently bi-directional.

The ES-FLOW™ 1xxC can be operated with analog signals or digitally with RS-232 communication (ProPar) or an extensive range of fieldbus protocols. An on-board PID controller can be used to drive a control valve or pump, establishing a complete yet compact control loop.

This document covers general product information, installation and operating instructions and troubleshooting tips for the ES-FLOW™ 1xxC.

1.2 Intended use

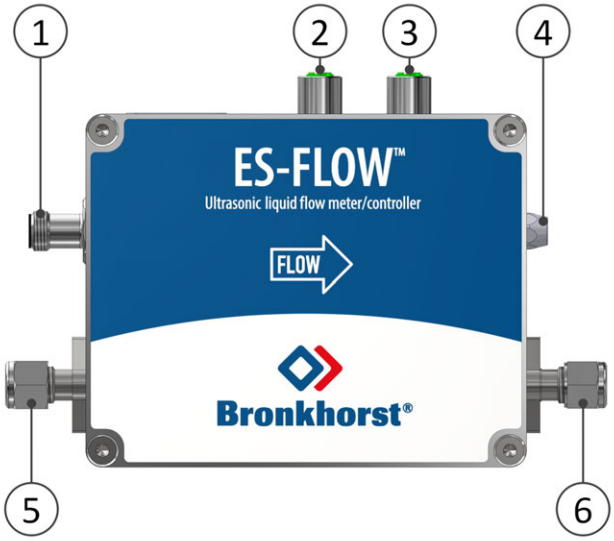
The **ES-FLOW™ 1xxC** has been developed to accurately measure and/or control volume flow rates of liquids in a fluid system, with high precision and a limited pressure drop. The device is suited for general purpose indoor (dry) applications, like laboratories and machine enclosures.

Any other use than mentioned here is considered unintended.

Responsibility for the use of the equipment with regard to its intended use, suitability for the intended application, cleaning and compatibility of process media with the applied materials lies solely with the end user.

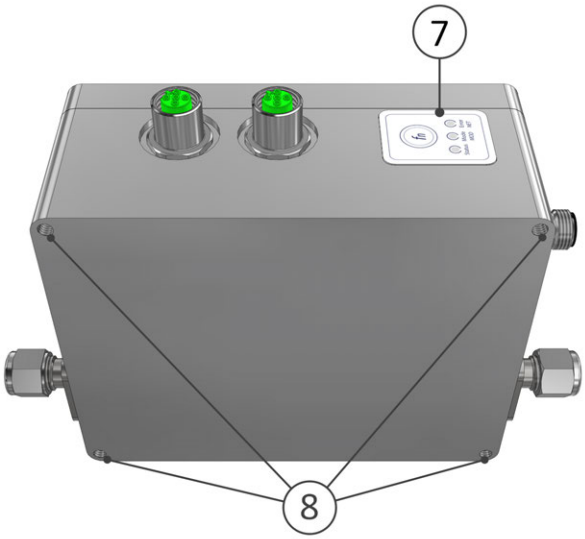
Bronkhorst High-Tech B.V. cannot be held liable for any damage and/or injury resulting from unintended, improper or unsafe use, or use with other media and/or under other process conditions than specified at ordering time.

1.3 Product overview



Front

1. Power & signal connector
2. Fieldbus connector 1 (optional)
3. Fieldbus connector 2 (optional)
4. Actuator output connector
5. Fluid inlet
6. Fluid outlet



Rear & top

7. Indication LEDs and multifunctional switch
8. Mounting holes

1.4 Documentation

- *This document contains basic information for installation, operation and maintenance of the ES-FLOW™.*
- *At some points it refers to documentation associated with important components or features. These references are listed in the table below.*
- *Documents listed here that are not included in the scope of delivery can be downloaded from* ***www.bronkhorst.com/downloads*** *or provided digitally on request.*

Type	Document name	Document no.
Manuals	Instruction Manual ES-FLOW™ 1xxC (this document)	9.17.153
	Manual CANopen interface	9.17.131
	Manual DeviceNet™ interface	9.17.026
	Manual EtherCAT® interface	9.17.063
	Manual EtherNet/IP interface	9.17.132
	Manual FLOW-BUS interface	9.17.024
	Manual Modbus interface	9.17.035
	Manual POWERLINK interface	9.17.142
	Manual PROFIBUS DP interface	9.17.025
	Manual PROFINET interface	9.17.095
	Manual RS-232 interface	9.17.027
Technical documentation	Dimensional drawing	7.15.220
	Hook-up diagram Analog/RS-232	9.16.254
	Hook-up diagram CANopen	9.16.259
	Hook-up diagram DeviceNet™	9.16.255
	Hook-up diagram EtherCAT® / EtherNet/IP / Modbus-TCP / POWERLINK / PROFINET	9.16.264
	Hook-up diagram FLOW-BUS	9.16.256
	Hook-up diagram Modbus	9.16.257
	Hook-up diagram PROFIBUS DP	9.16.258
	Hook-up diagram optional bus and I/O configurations	9.16.260
Compliance	EU Declaration of Conformity (EMC, RoHS)	9.06.021
	Declaration of Conformity (REACH, WEEE)	9.06.056

2 Safety instructions

2.1 General precautions

Please read this document entirely and carefully before installing and operating the product. Not following the guidelines could result in personal injury and damage to the product and the system(s) it is incorporated in or connected with.

The product(s) described in this document may only be used by qualified personnel who are familiar with combined fluid and electrical systems and who recognize the associated hazards (e.g. (high) fluid pressure, electric shock).

The end user is considered to be familiar with the required safety precautions to prevent damage and/or injury while working with the process media (as described in the associated Material Safety Data Sheets) and the equipment.

Where appropriate, this document recommends or prescribes safety measures to be taken with respect to media or equipment usage under the specified conditions. The end user is responsible for taking the necessary safety precautions and proper use of appropriate (personal) protective equipment, even if such is not explicitly recommended or required in this document.

The equipment and its accessories must be used in accordance with their specifications and operating instructions.

Individual instruments may not be disassembled or modified in any way for any purpose. Any unauthorized modification, for any purpose whatsoever, will be considered unintended and improper use, will void warranty and cancel the manufacturer's liability. Unauthorized modifications can undo safety features, compromise system specifications (such as ingress protection rating) and cause failure to comply with applicable laws, regulations and directives.

If the product is defective or otherwise does not meet your requirements, please contact your Bronkhorst representative for assistance or advice.

2.2 Tips and warnings

At the factory the ES-FLOW™ has been pressure tested. The test pressure includes a safety factor, so that it is always higher than the specified maximum operating pressure (pressure rating). Only in exceptional cases, the operating pressure may exceed the specified maximum operating pressure very briefly. The operating pressure must never exceed the specified test pressure.

- *The pressure rating and the test pressure are specified on the serial number label; if these specifications are missing or insufficient, the device must not be used and should be returned to the factory.*
- *Before installation, make sure that the pressure rating is within the limits of the normal process conditions and that the test pressure is in accordance with the safety factor of your application.*
- *Disassembling the device and/or replacing parts will invalidate the specification of the test pressure.*

Before commissioning, always check the wetted materials for compatibility with the process media.

Do not apply fluid pressure until all required fluid connections and electrical connections have been made.

Check the fluid system for leaks before applying full operating pressure, especially when using hazardous media (e.g. toxic or flammable).

*The equipment described in this document contains electronic components that are susceptible to **electrostatic discharge**. In order to prevent damage, proper handling procedures must be followed during installation, (dis)connecting and removing the electronics.*

*The equipment carries the CE-mark and is **compliant with the concerning EMC requirements**. However, EMC requirements can only be met using appropriate cables and connector/gland assemblies. Bronkhorst recommends the use of their standard cables. These cables have the right connectors and loose ends (if any) are marked to help prevent wrong connection. When using other cables, cable wire diameters must be sufficient to carry the supply current, and voltage loss must be kept as low as possible.*

*When connecting the product to other devices, be sure that the integrity of the shielding is not affected; **always use shielded cabling for signals and communication and do not use unshielded wire terminals.***

When in doubt about the suitability of your cabling, contact your Bronkhorst representative.

Always isolate the electrical power before connecting or disconnecting equipment.

When applying pressure, avoid pressure shocks and bring the fluid system gradually up to the level of the required operating conditions; open the fluid supply gently.

Bronkhorst does the utmost to ensure that you receive a clean product. This does not, however, relieve the end user of the responsibility to ensure that the instrument and the system in which it is incorporated meet the requirements implied by the intended use of the instrument. The responsibility for cleaning the equipment to meet such requirements lies exclusively with the end user.

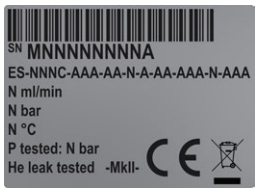
- *Prior to powering down the ES-FLOW™, the fluid system should be depressurized.*
- *When depressurizing, prevent sudden pressure changes by shutting off the fluid supply gradually.*

Inexpertly servicing instruments can lead to serious personal injury and/or damage to the instrument or the system it is used in. Servicing must therefore be performed by trained and qualified personnel. Contact your Bronkhorst representative for information about cleaning and calibration. Bronkhorst has a trained staff available.

- *Before disconnecting or disassembling any fluid system related parts, always make sure the fluid system is depressurized.*
- *When depressurizing, prevent sudden pressure changes by shutting off the fluid supply gradually.*

Frequent inspection of all fluid lines and connections before, during and after operation is essential, to ensure and maintain a safe working environment. If necessary, re-tighten fluid connections.

3 Product specifications



Before installing the ES-FLOW™, check that the product specifications match your requirements.

The model key (second line on the serial number label) contains information about the technical properties of the product as ordered. The actual properties of your product can be retrieved from the diagram below.

If you have a question about the product or if you find the product does not meet the specifications agreed upon, do not hesitate to contact your Bronkhorst representative. To enable us to help you quickly and effectively, make sure to have the serial number (SN) ready whenever seeking contact with your Bronkhorst representative about a specific item.

See section Service for contact information.

3.1 Pressure rating

At the factory the ES-FLOW™ has been pressure tested. The test pressure includes a safety factor, so that it is always higher than the specified maximum operating pressure (pressure rating). Only in exceptional cases, the operating pressure may exceed the specified maximum operating pressure very briefly. The operating pressure must never exceed the specified test pressure.

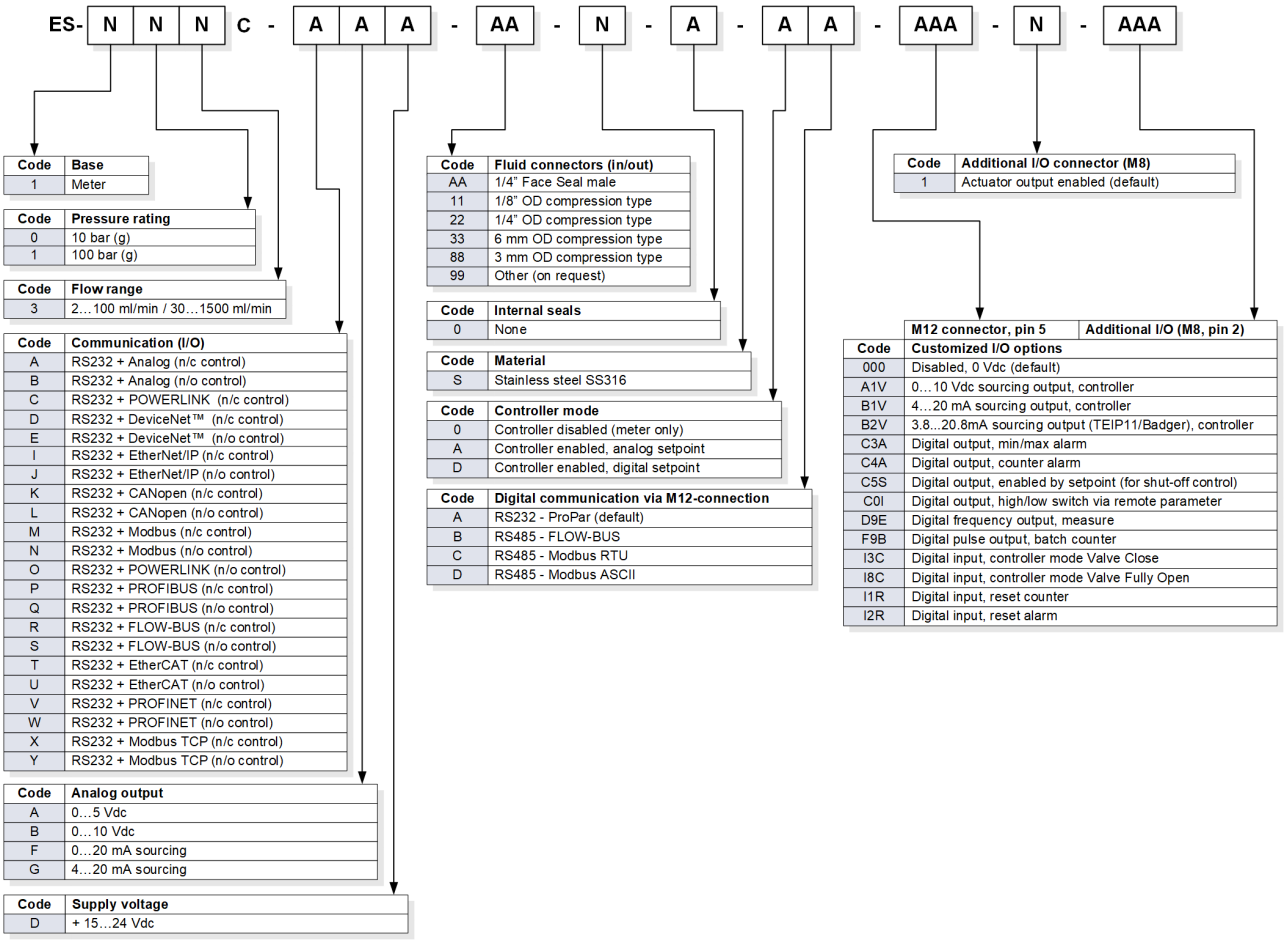
- *The pressure rating and the test pressure are specified on the serial number label; if these specifications are missing or insufficient, the device must not be used and should be returned to the factory.*
- *Before installation, make sure that the pressure rating is within the limits of the normal process conditions and that the test pressure is in accordance with the safety factor of your application.*
- *Disassembling the device and/or replacing parts will invalidate the specification of the test pressure.*

3.2 Wetted materials

Before commissioning, always check the wetted materials for compatibility with the process media.

3.3 Model key

The model key on the serial number label contains information about the technical properties of the product as ordered. The actual properties of your instrument can be retrieved from the diagram below.



Code	Base
1	Meter

Code	Pressure rating
0	10 bar (g)
1	100 bar (g)

Code	Flow range
3	2…100 ml/min / 30…1500 ml/min

Code	Communication (I/O)
A	RS232 + Analog (n/c control)
B	RS232 + Analog (n/o control)
C	RS232 + POWERLINK (n/c control)
D	RS232 + DeviceNet™ (n/c control)
E	RS232 + DeviceNet™ (n/o control)
I	RS232 + EtherNet/IP (n/c control)
J	RS232 + EtherNet/IP (n/o control)
K	RS232 + CANopen (n/c control)
L	RS232 + CANopen (n/o control)
M	RS232 + Modbus (n/c control)
N	RS232 + Modbus (n/o control)
O	RS232 + POWERLINK (n/o control)
P	RS232 + PROFIBUS (n/c control)
Q	RS232 + PROFIBUS (n/o control)
R	RS232 + FLOW-BUS (n/c control)
S	RS232 + FLOW-BUS (n/o control)
T	RS232 + EtherCAT (n/c control)
U	RS232 + EtherCAT (n/o control)
V	RS232 + PROFINET (n/c control)
W	RS232 + PROFINET (n/o control)
X	RS232 + Modbus TCP (n/c control)
Y	RS232 + Modbus TCP (n/o control)

Code	Analog output
A	0…5 Vdc
B	0…10 Vdc
F	0…20 mA sourcing
G	4…20 mA sourcing

Code	Supply voltage
D	+ 15…24 Vdc

Code	Fluid connectors (in/out)
AA	1/4" Face Seal male
11	1/8" OD compression type
22	1/4" OD compression type
33	6 mm OD compression type
88	3 mm OD compression type
99	Other (on request)

Code	Internal seals
0	None

Code	Material
S	Stainless steel SS316

Code	Controller mode
0	Controller disabled (meter only)
A	Controller enabled, analog setpoint
D	Controller enabled, digital setpoint

Code	Digital communication via M12-connection
A	RS232 - ProPar (default)
B	RS485 - FLOW-BUS
C	RS485 - Modbus RTU
D	RS485 - Modbus ASCII

Code	Additional I/O connector (M8)
1	Actuator output enabled (default)

	M12 connector, pin 5	Additional I/O (M8, pin 2)
Code	Customized I/O options	
000	Disabled, 0 Vdc (default)	
A1V	0…10 Vdc sourcing output, controller	
B1V	4…20 mA sourcing output, controller	
B2V	3.8…20.8mA sourcing output (TEIP11/Badger), controller	
C3A	Digital output, min/max alarm	
C4A	Digital output, counter alarm	
C5S	Digital output, enabled by setpoint (for shut-off control)	
C0I	Digital output, high/low switch via remote parameter	
D9E	Digital frequency output, measure	
F9B	Digital pulse output, batch counter	
I3C	Digital input, controller mode Valve Close	
I8C	Digital input, controller mode Valve Fully Open	
I1R	Digital input, reset counter	
I2R	Digital input, reset alarm	

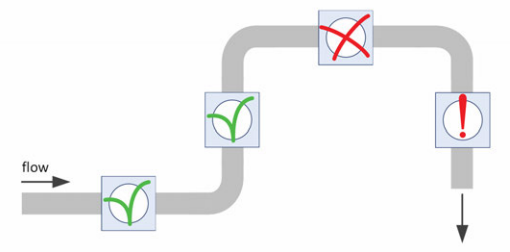
4 Installation

4.1 Mounting

For stable fixation to a rigid and stable surface or construction, use the threaded mounting holes in the rear of the instrument housing (see product overview). Consult the dimensional drawing for the exact size and locations.

4.1.1 Location

Gas bubbles in the liquid can lead to measuring errors. In general, the instrument should be mounted in a pipe segment where gas bubbles cannot accumulate. The image on the right shows the preferable mounting locations.



- In general, the best location is a horizontal pipe segment or a segment where the fluid direction is upward.
- Gas might accumulate in the horizontal segment if it is followed by a downward segment. Do not mount the instrument in a location like this.
- Mounting in a downward pipe segment with an open end is strongly dissuaded, especially if the pipe diameter is 1/2" or more. Gravity might let the segment run empty; depending on the specific system dimensions and the viscosity of the metered fluid, this effect might be stronger or weaker.
- If the instrument is part of a closed fluid system, mounting the instrument in a downward pipe segment is not preferable, but may be considered if other mounting locations are problematic.

To minimize the risk of gas bubbles caused by cavitation, the preferred location to install a (control) valve is downstream from the instrument, the preferred location for a pump is upstream.

To prevent damage to the internal electronics, make sure the temperature inside the instrument housing does not get above 60 °C. If necessary, take appropriate heat dissipation measures, especially if the instrument is operated inside an enclosure (e.g. a control cabinet).

4.1.2 Orientation

Aside from specific application requirements, the ES-FLOW™ has no preferred mounting orientation.

4.2 Fluid connections

For regular (mono-directional) use, install the ES-FLOW™ in the process line, in accordance with the direction of the FLOW arrow on the instrument. For bi-directional measuring, install the instrument in the direction in which the highest flow will be measured (if applicable). When deciding which direction to install the instrument in, take into account that the measuring range in the reverse direction is approximately 73% of the full scale range (whereas the instrument can measure 131% FS in the normal direction).

Tighten fittings according to the instructions issued by their manufacturer.

Do not apply fluid pressure until all required fluid connections and electrical connections have been made.

Check the fluid system for leaks before applying full operating pressure, especially when using hazardous media (e.g. toxic or flammable).

4.3 Electrical connections

- Electrical connections must be made with standard cables or compatible, according to the hook-up diagram.
- When using self-assembled cables, follow the guidelines provided by the connectors' manufacturer.
- For use in a fieldbus system, follow the instructions of the cable supplier for the according fieldbus system.
- Make sure that the power supply is suitable for the power ratings as indicated on the serial number label (model key), and that double or reinforced insulation is used for the power supply.
- Before powering up, make sure all required cabling is properly connected.
- Before each use, inspect cabling and connectors for damage.

The equipment described in this document contains electronic components that are susceptible to ***electrostatic discharge****. In order to prevent damage, proper handling procedures must be followed during installation, (dis)connecting and removing the electronics.*

The equipment carries the CE-mark and is ***compliant with the concerning EMC requirements****. However, EMC requirements can only be met using appropriate cables and connector/gland assemblies. Bronkhorst recommends the use of their standard cables. These cables have the right connectors and loose ends (if any) are marked to help prevent wrong connection. When using other cables, cable wire diameters must be sufficient to carry the supply current, and voltage loss must be kept as low as possible.*

When connecting the product to other devices, be sure that the integrity of the shielding is not affected; ***always use shielded cabling for signals and communication and do not use unshielded wire terminals.***

When in doubt about the suitability of your cabling, contact your Bronkhorst representative.

Always isolate the electrical power before connecting or disconnecting equipment.

4.4 Fieldbus connection

Never *power the instrument simultaneously from* ***two different power sources*** *(e.g. fieldbus and Plug-in Power Supply). Doing so will irreversibly damage the printed circuit board and the instrument will have to be repaired before it can be used.*

Always check the total power consumption of your instruments before connecting them to a fieldbus system. Do not exceed the maximum power of the power supply unit.

- *For information about setting up a fieldbus network with Bronkhorst® instruments, consult the according fieldbus manual.*
- *If you need assistance with setting up a fieldbus network, contactyour Bronkhorst representative for information.*

5 Operation

5.1 Powering up

To maintain control of the fluid system and ensure a safe situation, it is recommended to turn on power before applying fluid pressure and to switch off power only after the fluid system is depressurized.

When applying pressure, avoid pressure shocks and bring the fluid system gradually up to the level of the required operating conditions; open the fluid supply gently.

- After powering up, the instrument needs a couple of seconds to start up the electronics and perform a self-test. After successful initialization, the green LED will light up continuously to indicate that the instrument is ready to use.
- If the sensor tube contains gas, the red LED will light up continuously and the instrument will issue a warning code by means of parameter *Alarm Info* (see Alarms).

5.2 First use

Bronkhorst does the utmost to ensure that you receive a clean product. This does not, however, relieve the end user of the responsibility to ensure that the instrument and the system in which it is incorporated meet the requirements implied by the intended use of the instrument. The responsibility for cleaning the equipment to meet such requirements lies exclusively with the end user.

Before starting measurement and control, make sure to remove gas from the fluid system by flushing all fluid lines with the process fluid at a high flow rate.

5.3 Powering down

- *Prior to powering down the ES-FLOW™, the fluid system should be depressurized.*
- *When depressurizing, prevent sudden pressure changes by shutting off the fluid supply gradually.*

5.4 Control valve

This section is only applicable if the ES-FLOW™ is used in conjunction with a control valve.

5.4.1 Bleeding

In order to ensure stable and reliable control behavior, the dead space of the control valve should be kept free of gas, by bleeding it from time to time. Bleeding is advised at the following occasions:

- prior to first use
- when restarting the instrument after purging
- periodically, to remove accumulated gas

- *Make sure to connect the bleed outlet to an appropriate draining facility, especially if the system is used to process hazardous media.*
- *Take appropriate safety measures, as described in the Material Safety Data Sheet(s) of the media to be processed (if applicable).*

Install a shut-off valve as close to the bleed outlet as possible and connect a clear transparent tube to the valve outlet; being able to see gas bubbles in the liquid will ease monitoring the progress of the bleeding procedure

To bleed the control valve, follow this procedure:

1. Change the liquid flow setpoint to 0% (this closes the valve)
2. Pressurize the liquid inlet (if not already done so)
3. Open the bleed outlet (slowly) until liquid starts to escape
4. Optionally, tap the valve assembly and/or liquid inlet of the valve to let gas bubbles accumulate and migrate to the valve
5. Close the bleed outlet as soon as all gas has escaped the control valve

5.4.2 Default valve state

When the instrument is not powered or cannot communicate with the fieldbus network (if applicable), the control valve automatically returns to its default state, which is closed for 'normally closed' valves (n/c) and fully open for 'normally open' valves (n/o). Taking into account the typical process conditions under which the instrument is used (such as the processed media and ambient conditions; see also Intended use), the default state is generally considered safe.

5.5 Hardware controls

On top of the housing the instrument is equipped with a multifunctional switch (fn) and three indication LEDs:

Status	Communication interface status
Mode/MOD	Operational mode
Error/NET	Error/warning indication

- During normal operation the *Mode/MOD* indicator is lit green ● continuously, while the *Error/NET* indicator flashes red ● when data is being transferred.
- During initialization and special procedures, the *Mode/MOD* indicator blinks or flashes.
- See the troubleshooting guide for general error indications and possible causes.
- Several other indications are specific to the installed communication interface.
- The *Status* LED is functional only if the instrument is equipped with an Ethernet based fieldbus interface.
- Consult the according interface manual for a list of all indications.

5.5.1 Multifunctional switch

Some special instrument functions can be started manually using the multifunctional switch near the indication LEDs. These functions are available in analog as well as in digital operation mode.

5.5.1.1 Normal operating functions

- In order to access these functions, press and hold the switch while the instrument is in normal operation mode (green LED lit continuously).
- As long as the switch is held, the LEDs show a repeating sequence of patterns, where each pattern indicates a function.
- All patterns in this sequence are continuous.
- Each pattern is shown for a number of seconds; in the table below, the column labeled *Hold time* indicates the time frame within the sequence during which a pattern is shown.
- To start a function, release the switch when the LEDs show the pattern of the required function.

● (green)	● (red)	Hold time	Function
off	off	0…1 sec	No action
off	off	1…4 sec	1. In case of a min/max alarm: reset alarm 2. FLOW-BUS: Auto-install to bus - lets instrument obtain free node address if configured node address is occupied Note: min/max alarm (if any) has to be reset before auto install can be performed.
off	on	4…8 sec	Reset instrument; clear all warnings and error messages and restart the instrument
on	off	8…12 sec	Auto-zero; re-adjust the zero-point of the instrument (flow meters/controllers only)
on	on	12…16 sec	Enable FLASH mode for firmware update: • the instrument shuts down and both LEDs are switched off • at the next power-up, the instrument will be active again

- *See Adjusting zero point for background information and instructions on how to adjust the zero point of an instrument.*
- *Do not perform a zeroing procedure before having taken notice of the instructions.*

5.5.1.2 Control mode - readout/change

Reading control mode

- By briefly pressing the switch 2 times with intervals of up to 1 second in normal operation mode, the instrument shows its current control mode with a series of consecutive LED indication patterns.
- The number of flashes corresponds to the current value of parameter *Control Mode* (see Special parameters).

Step	Pattern		Indication
1.	Green	● ○	number of flashes indicates the tens of the parameter value
2.	Red	○ ●	number of flashes indicates the units of the parameter value

Examples:

- for value 1 (control mode 'Analog input'), the green LED will flash 0 times and the red LED 1 time
- for value 22 (control mode 'Valve Safe State'), the green and red LED will each flash 2 times

Changing control mode

- By briefly pressing the switch 4 times with intervals of up to 1 second in normal operation mode, the instrument enters a state in which the control mode can be changed.
- This is done in 2 steps, each represented by a LED indication pattern (green or red; see table below).
- The number of flashes corresponds to the available values of parameter *Control Mode* (see Special parameters).
- At the start of each step, the according LEDs starts flashing fast (0.1 second on, 0.1 second off). By pressing and holding the switch, the associated action is started and the flashing slows (05. seconds on, 0.5 seconds off).

Step	Pattern		Maximum flash count	Action
1.	Green	● ○	2	set tens of parameter value
2.	Red	○ ●	9	set units of parameter value

To execute a step, follow these instructions:

- Press and hold the switch (flashing slows)
- To select value 0 (zero), release the switch within 1 second, otherwise:
- Count the number of LED flashes
- Release the switch when the required value is reached
- In case you lose count, keep the switch pressed and wait until the flash count reaches its maximum and restarts

On completion of step 1, the instrument automatically advances to step 2. When both steps have been completed, the instrument returns to its normal operation mode.
If the switch is not pressed within 60 seconds after starting a step, all changes are canceled and the instrument returns to its normal operation mode.

Note that this procedure also sets the default control mode of the instrument (contrary to changing the control mode digitally).

5.5.1.3 Network settings - readout/change

Reading network settings

- By briefly pressing the switch 3 times with intervals of up to 1 second in normal operation mode, the instrument shows its current node address and baud rate with a series of consecutive LED indication patterns:

Step	Pattern		Indication
1.	Green	● ○	number of flashes indicates the tens of the node address
2.	Red	○ ●	number of flashes indicates the units of the node address
3.	Green and red (simultaneous)	● ●	number of flashes indicates the baud rate

Examples:

- for node address 35, the green LED will flash 3 times and the red LED 5 times
- for node address 116, the green LED will flash 11 times and the red LED 6 times

On DeviceNet™ the node address is called MAC ID.

The number of flashes for the baud rate indication is associated with the following baud rates:

Number of flashes (index)	Baud rate					
	FLOW-BUS	Modbus (ASCII/RTU)	PROFIBUS DP	CANopen	DeviceNet™	Ethernet based
0			automatically detected			
1	187500	9600	9600	1000000	125000	100000000
2	400000	19200	19200	800000	250000	
3		38400	45450	500000	500000	
4		56000	93750	250000		
5		57600	187500	125000		
6		115200	500000	50000		
7		128000	1500000	20000		
8		256000	3000000	10000		
9			6000000			
10			12000000			

Changing network settings

- By briefly pressing the switch 5 times with intervals of up to 1 second in normal operation mode, the instrument enters a state in which the node address and baud rate can be changed (non-Ethernet based protocols only; for Ethernet based protocols, network parameters are configured by the fieldbus master and cannot be set on the instrument).
- Changing network parameters with the multifunctional switch is done in 3 steps, each represented by a LED indication pattern (see table below).
- At the start of each step, the according LED(s) start(s) flashing fast (0.1 second on, 0.1 second off). By pressing and holding the switch, the associated action is started and the flashing slows (05. seconds on, 0.5 seconds off).

Step	Pattern		Maximum flash count	Action
1.	Green	● ○	12	set tens of node address
2.	Red	○ ●	9	set units of node address
3.	Green and red (simultaneous)	● ●	10*	set baud rate index (number of flashes)

*) maximum count depends on the supported baud rates of the fieldbus. See the baud rate table above for supported baud rates and associated indexes.

To execute a step, follow these instructions:

- Press and hold the switch (flashing slows)
- To select value 0 (zero), release the switch within 1 second, otherwise:
- Count the number of LED flashes
- Release the switch as soon as the required value is reached
- In case you lose count, keep the switch pressed and wait until the flash count reaches its maximum and restarts

On completion of a step, the instrument automatically advances to the next step. When all required steps have been completed, the instrument returns to its normal operation mode.
If the switch is not pressed within 60 seconds after starting a step, all changes in the previous steps are cancelled and the instrument returns to its normal operation mode.

5.5.1.4 Disabling multifunctional switch

To prevent unwanted use of the multifunctional switch, it can be disabled through the digital interface using the following procedure:

1. Set parameter *Init reset* to 64
2. Read parameter *IO status*
3. Subtract 8 from the read value
4. Write the new value to parameter *IO status*
5. Set parameter *Init reset* to 82

To re-enable the switch, add 8 to the value of *IO status* in step 3.

5.6 Adjusting zero point

Zero-stability

The zero point of a Bronkhorst® flow meter/controller (the measurement signal that indicates the absence of a flow) is factory adjusted with water, at approximately 20 °C and atmospheric pressure (ambient conditions), with the instrument positioned upright. Under normal circumstances, the zero point will remain stable. However, in rare cases (for example due to strong fluctuations in temperature and/or pressure), the instrument might develop a zero-stability error over time, causing it to detect a flow when actually there is none. The zero-stability error can be neutralized by re-adjusting the zero point.

If the instrument still detects a (steady) flow while all valves are closed and the fluid system is leak tight, re-adjusting the zero point is recommended.

Prerequisites
Zeroing an instrument requires that:

- the ambient conditions (temperature, pressure) match those of the operating environment of the instrument
- the instrument is filled homogeneously and pressurized with the operational media, according to the typical process conditions
- there is absolutely no flow through the instrument; preferably, this is achieved by closing a valve immediately after the outlet of the instrument (control valve, shut-off valve)

Blocking the flow through the instrument is essential; zeroing an instrument while there is still a flow will lead to measurement errors.

Procedure
The zeroing procedure can be performed manually (using the multifunctional switch) or digitally, with RS-232 or fieldbus communication

Regardless of the chosen method, the zeroing procedure takes approximately 25 seconds to complete.

5.6.1 Manual procedure

To start the autozero function with the multifunctional switch, follow these instructions:

1. Change the setpoint of the instrument to 0 (zero)
2. Press and hold the multifunctional switch. After 4 seconds, the red LED ● will light up; another 4 seconds later the red LED will extinguish and the green LED ● will light up
3. At that moment (which is after 8 to 12 seconds), release the switch

The green LED will start to blink fast, indicating that the autozero function is in progress. After (successful) completion, the green LED will glow continuously, while the output signal is 0% (parameter *Measure* = 0).

5.6.2 Digital procedure

FlowPlot and FlowSuite provide an easy way to adjust the zero point of an instrument with RS-232 communication; the Autozero *function automatically performs the procedure described here.*

To adjust the zero point using digital communication, set parameter values in the following sequence (see section Parameters for more information about instrument parameters):

Sequence #	Parameter	Value	Action
1	Setpoint	0	stop flow (close control valve)
2	Init Reset	64	unlock secured parameters
3	Control Mode	9	enable calibration mode
4	Calibration Mode	0	reset calibration mode
5	Calibration Mode	9	start zeroing

On completion of the procedure, parameter *Control Mode* returns to its initial value. If the procedure is successful, parameter *Calibration mode* changes to 0 (idle). If the procedure fails, *Calibration Mode* changes to 255.

After performing the procedure, remember to set parameter Init Reset *to value 0 to lock secured parameters.*

5.6.3 Digital procedure on PROFIBUS DP

For instruments with a PROFIBUS DP interface, the procedure to be followed differs slightly:
To adjust the zero point through bus communication in a PROFIBUS DP system, set (write) parameter values in the following sequence (see section Parameters for more information about instrument parameters):

Sequence #	Parameter	Value	Action
1	Setpoint	0	stop flow (close control valve)
2	Initreset	64	unlock secured parameters
3	Calibration mode	0	reset calibration mode
4	Calibration mode	22	start zeroing
5	Calibration mode	0	reset calibration mode

Calibration mode *must be reset after the zeroing procedure is started, but before the procedure finishes. By keeping* Calibration mode *at value 22, the zeroing procedure will be started again immediately after it finishes.*
The zeroing procedure takes approximately 25 seconds to complete (longer if the output signal is unstable).

After starting the zeroing procedure, the value of parameter *Calibration mode (read)* changes to 9, to indicate the procedure is running. Upon completion, *Calibration mode (read)* changes to 0 if the procedure is successful; if the procedure fails, it changes to 255.

After performing the procedure, remember to set parameter Initreset *to value 0 to lock secured parameters*

6 Digital communication

RS-232 communication

Digital Bronkhorst® instruments can be monitored and operated via RS-232 using the free **FlowWare** software tools for Windows. These tools provide a graphical interface to the ProPar protocol, for monitoring and changing instrument parameters.

The FlowWare toolkit provides functionality for monitoring and operating digital instruments (FlowPlot, FlowSuite), selection of the active fluid and fieldbus configuration (if applicable). For instruments that support the definition and use of multiple fluids FlowTune™ can be used to define and store fluids in the instrument and select the active fluid.

Digital instrument parameters are made accessible by **FlowDDE**, a Dynamic Data Exchange server (DDE) that handles communication between the instrument and (dedicated) client software in Windows (e.g. FlowPlot). FlowDDE can also be used by other client applications, such as Microsoft Office or custom made software, built with third party development software like LabVIEW or a SCADA platform.

The FlowWare tools and associated documentation can be downloaded from the product pages on the Bronkhorst website: ***www.bronkhorst.com/products***

For more information about communication through the RS-232 interface, consult the RS-232 manual.

Fieldbus communication

For information about parameter access and availability for Bronkhorst® instruments in a specific fieldbus network, consult the according fieldbus manual.

6.1 Parameters

This section describes the most commonly used parameters for digital operation of the ES-FLOW™. Descriptions are grouped by category in tables as shown below:

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
[type]	RW 🔑	[x]…[y]	[DDE par]	[Pro]/[Par]	[address]/[register]

In this manual, parameter names are printed in italics (reverted to normal *where embedded in italics, like in this tip).*

Type

Unsigned char	1 byte unsigned integer (0…255)
Unsigned int	2 byte unsigned integer, MSB first (0…65535)
Unsigned long	4 byte unsigned integer, MSB first (0…4294967295)
Float	4 byte floating point, IEEE 32-bit single precision, MSB first
Unsigned char [x]	x byte array (text string)

Access

R	Parameter value can be read
W	Parameter value can be written
🔑	Parameter is secured and only accepts values if parameter *Init Reset* is set to 'unlocked' first

Range

Some parameters only accept values within a certain range:

[x]	Minimum value of the range
[y]	Maximum value of the range

FlowDDE

Parameter number within FlowDDE

FLOW-BUS
Within the FLOW-BUS protocol (ProPar when using RS-232 communication), parameters are identified by a unique combination of a process number and a parameter number:
[Pro] Process number
[Par] Parameter number

For more detailed information, consult the RS-232 manual (see Documentation).

Modbus
In the Modbus protocol, parameters are accessed by specifying their unique decimal register number or corresponding PDU address (Protocol Data Unit). The PDU address is the hexadecimal translation of the register number minus 1, e.g. register number 1 corresponds to PDU address 0x0000, register number 11 corresponds to PDU address 0x000A:
[address] Hexadecimal PDU address
[register] Decimal register number

Modbus address blocks are two bytes big. Larger data types use up to 8 subsequent address blocks, resulting in a maximum variable length of 16 bytes. Values longer than the maximum length are truncated.

For more detailed information, consult the Modbus manual (see Documentation).

Other interface protocols
Parameter descriptions in this document are based on their availability with FLOW-BUS, Modbus or RS-232 (ProPar) communication. Due to limitations in, for example, memory capacity or communication properties, definition files for other fieldbus systems usually do not make all parameters available.

For information about parameter access and availability for Bronkhorst® instruments in a specific fieldbus network, consult the according fieldbus manual.

6.1.1 Measurement and control

Measure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	R	0…41942 (65535*)	8	1/0	0x0020/33

This parameter indicates the flow metered by the instrument. The value of 32000 corresponds to 100%, the maximum measured value output is 131.07%, which translates to 41942.

**In case the instrument is prepared for bi-directional measurement, the negative signals with an output range of -73.73…-0.003% are represented by the range of 41943…65535, whereas the positive signals 0…131.07% are still represented by the range of 0…41942. (FlowDDE converts the numbers to negative values automatically).*

Setpoint

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…32000	9	1/1	0x0021/34

This parameter is used to set the required flow rate for the controller. The signals have the same range as *Measure*, but the setpoint range is limited between 0 and 100% (0…32000).

6.1.1.1 Advanced measurement and control

Fmeasure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	R	-3.4E+38… 3.4E+38	205	33/0	0xA100…0xA101/ 41217…41218

Floating point variant of *Measure*. *Fmeasure* shows the measured value in the capacity unit for which the instrument is set. The instrument uses parameters *Capacity*, *Capacity 0%*, *Capacity Unit* and *Sensor Type* to calculate *Fmeasure*.

Fsetpoint

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	206	33/3	0xA119…0xA11A/ 41241…41242

Floating point variant of *Setpoint*. *Fsetpoint* shows the setpoint in the capacity unit for which the instrument is set. Like *Fmeasure*, *Fsetpoint* is dependent of *Capacity*, *Capacity 0%*, *Capacity Unit* and *Sensor Type*.

Setpoint Slope

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…30000	10	1/2	0x0022/35

The value of this parameter represents the time it would take to adjust the setpoint if it were changed from 0 to 100%. This feature can be used to smooth 'nervous' controller behavior, e.g. to reduce setpoint overshoot or undershoot.
The supported range corresponds to 0…3000 seconds. Default value = 0.

Example:
If *Setpoint Slope* = 100 it will take 10 seconds to adjust the setpoint if it is changed from 0 to 100%. A setpoint change of 20% will take (20%/100%)*10 seconds = 2 seconds.

Analog Input

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	R	0…65535	11	1/3	0x0023/36

This parameter contains a digital translation of the analog input signal (if applicable).

Valve Output

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned long	RW	0… 16777215	55	114/1	0xF208…0xF209/61961…61962

This parameter represents the controller output signal for control valve operation.

6.1.1.2 Secondary outputs

Temperature

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	R	-250…500	142	33/7	0xA138…0xA139/41273…41274

This parameter returns the internal temperature in the instrument housing in °C.

6.1.2 Alarms

Alarm settings are most easily accessible using FlowSuite, FlowPlot or FlowView or a Bronkhorst® readout and control unit.

The built-in alarm functionality can be used to handle different alarm types:
- system errors and warnings
- min/max alarms
- response alarms
- batch alarms
- master/slave alarms

The alarm type can be set with parameter *Alarm Mode*. When an alarm is activated, the type can be read out using parameter *Alarm Info*. An automatic setpoint change can be set using the parameters *Alarm Setpoint Mode* and *Alarm New Setpoint*. It is also possible to set an alarm delay, to prevent overreaction to small disturbances, using parameter *Alarm Delay Time*. The methods by which an alarm can be reset are controlled by *Reset Alarm Enable*.

Alarm Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…3	118	97/3	0x0C23/3108

Available modes:

Value	Description
0	Alarm off
1	Alarm on absolute limits
2	Alarm on limits related to setpoint (response alarm)
3	Alarm at power-up(e.g. after power-down)

(On DeviceNet™ instruments, only modes 0 and 1 are available)

Alarm Info

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	R	0…255	28	1/20	0x0034/53

This parameter provides information about the event type(s) that triggered an alarm situation. The value is a bitwise summation of the issued alarm types; convert the value to binary to see which types are issued. The following alarm types can be issued:

Bit	Value	Type	Description
0	1	Error	Error flag raised
1	2	Warning	Warning flag raised
2	4	Minimum alarm	*Measure* < *Alarm minimum limit*
3	8	Maximum alarm	*Measure* > *Alarm maximum limit*
4	16	Batch counter alarm	Batch counter reached its limit
5	32	• This bit only: Power-up alarm	Alarm possibly caused by a power dip
		• If combined with bit 2 or 3: Response alarm	Difference between *Measure* and *Setpoint* too big
6	64	Master/slave alarm	Setpoint out of limits (caused by *Slave factor*)
7	128	Hardware alarm	Hardware error

Alarm Delay Time

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	182	97/7	0x0C27/3112

This value represents the time in seconds the alarm action will be delayed when an alarm limit has been exceeded. This value also delays the alarm off action if an alarm limit is no longer exceeded.
Default value = 0.

Alarm Maximum Limit

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…32000	116	97/1	0x0C21/3106

Maximum limit for *Measure* to activate the maximum alarm situation (after *Alarm Delay Time*). Range 0…32000 represents 0… 100% signal. *Alarm Maximum Limit* must be greater than *Alarm Minimum Limit*.
Default value: 0.

Alarm Minimum Limit

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…32000	117	97/2	0x0C22/3107

Minimum limit for *Measure* to activate the minimum alarm situation (after *Alarm Delay Time*). Range 0…32000 represents 0… 100% signal. *Alarm Minimum Limit* must be smaller than *Alarm Maximum Limit*.
Default value: 0.

Alarm Setpoint Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…1	120	97/5	0x0C25/3110

Specifies whether or not to change the setpoint after an alarm situation is activated.

Value	Description
0	No setpoint change (default)
1	Change setpoint to *Alarm new setpoint*

Alarm New Setpoint

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…32000	121	97/6	0x0C26/3111

New (safe) setpoint during an alarm until reset. Range 0…32000 represents 0…100% setpoint.
Default value: 0

Reset Alarm Enable

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…15	156	97/9	0x0C29/3114

Up to 4 different methods can be specified. The value is a bitwise summation of the enabled methods; convert the value to binary to see which methods are enabled.
Default value: 15 (all bits/methods enabled)

The following methods are supported:

Bit	Value	Description
0	1	Multifunctional switch
1	2	Externally (deprecated)
2	4	By parameter *Reset*
3	8	Automatically (when alarm conditions no longer apply)

6.1.3 Counter

Counter settings are most easily accessible using FlowSuite, FlowPlot or FlowView or a Bronkhorst® readout and control unit.

Counter Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…2	130	104/8	0x0D08/3337

Available modes:

Value	Description
0	Counter off (default)
1	Counting up continuously
2	Counting up until limit reached (set by *Counter Limit*)

Counter Unit

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[4]	RW	see table below	128	104/7	0xE838…0xE839/59449…59450

This parameter contains the name of the counter readout unit.

Counter Unit supports the following values:

Mass	Normal volume (1.01325 bar(a), 0 °C)	Standard volume (1.01325 bar(a), 20 °C)	Custom volume (*Capacity Unit Pressure*, *Capacity Unit Type Temperature*)
ug, mg, g, kg	uln, mln, ln, mm3n, cm3n, dm3n, m3n	uls, mls, ls, mm3s, cm3s, dm3s, m3s	ul, ml, l, mm3, cm3, dm3, m3

Counter Value

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0… 10000000	122	104/1	0xE808…0xE809/59401…59402

Current counter value in units selected with parameter *Counter Unit*.

Counter Limit

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…9999999	124	104/3	0xE818…0xE819/59417…59418

Counter limit/batch size in units selected with parameter *Counter Unit*.
Default value: 0.

Counter Setpoint Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…1	126	104/5	0x0D05/3334

Specifies whether or not to change the setpoint after reaching the counter limit.

Value	Description
0	No setpoint change (default)
1	Change setpoint to *Counter new setpoint*

Counter New Setpoint

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned int	RW	0…32000	127	104/6	0x0D06/3335

New (safe) setpoint when a counter limit is reached until reset. Range 0…32000 represents 0…100% setpoint.
Default value: 0

Reset Counter Enable

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…15	157	104/9	0x0D09/3338

Available reset methods for counters. Up to 3 different methods can be specified. The value is a bitwise summation of the enabled reset methods; convert the value to binary to see which methods are enabled.
Default value: 7 (bits/methods 0, 1 and 2 enabled)

The following methods are supported:

Bit	Value	Description
0	1	Multifunctional switch
1	2	Externally
2	4	By parameter *Reset*
3	8	Automatically (e.g. when counter value is reset)

6.1.4 Network configuration

*Changes made to the network settings will **not** be restored by a factory reset.*

Default configuration
Network configuration is done ex factory as indicated on the serial number label or in the technical specifications. The table below shows the supported configurations for the available interface protocols (default settings are printed in bold):

Protocol	ProPar (RS-232)	FLOW-BUS (RS-485)	Modbus (RTU/ASCII)	PROFIBUS DP	CANopen	DeviceNet™
Address	**3**	**3**…125	**1**…247	0…**126**	1…**127**	0…**63**
Baud Rate	9600 19200 **38400** 57600 115200 230400 460800	**187500** 400000	9600 **19200** 38400 56000 57600 115200 128000 256000	**(autodetect)** 9600 19200 45450 93750 187500 500000 1500000 3000000 6000000 12000000	10000 20000 50000 125000 250000 **500000** 800000 1000000	**125000** 250000 500000
Parity	**0**	**0**	0, 1, **2**	**2**	**0**	**0**

Network configuration for Ethernet based fieldbus types is done automatically via the Ethernet protocol.

Communication via fieldbus connector (RS-485)
Use the following parameters to configure the instrument for communication through the fieldbus connector (5-pin M12):

Fieldbus 1 Address

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	199	125/10	0x0FAA/4011

Fieldbus 1 Baud Rate

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned long	RW	0…1.0E10	201	125/9	0xFD48…0xFD49/64841…64842

Fieldbus 1 Parity

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…2	335	125/12	0x0FAC/4013

The following values are supported:

Value	Description
0	No parity
1	Odd parity
2	Even parity

Communication via standard connector (RS-232/RS-485)
Use the following parameters to configure the instrument for communication through the 8-pin M12 connector:

Fieldbus 2 Address

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	309	124/10	0x0F8A/3979

Fieldbus 2 Baud Rate

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned long	RW	0…1.0E10	310	124/9	0xFC48…0xFC49/64585…64586

Fieldbus 2 Parity

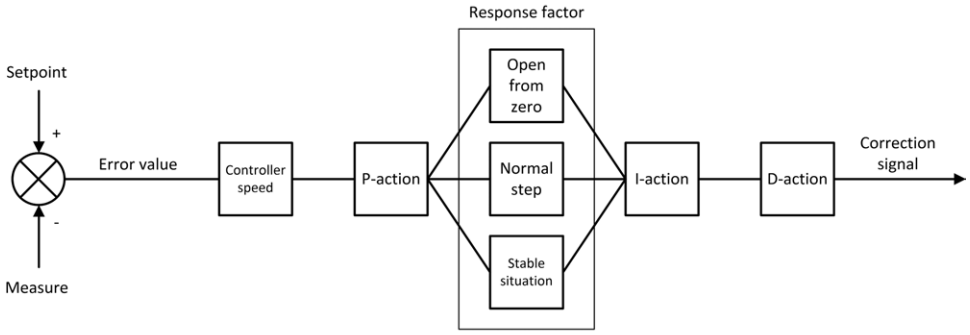
Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…2	336	124/12	0x0F8C/3981

The following values are supported:

Value	Description
0	No parity
1	Odd parity
2	Even parity

6.1.5 Controller

The picture below shows a basic diagram of the PID controller algorithm (proportional, integral, derivative) used by digital Bronkhorst® instruments.



The controller speed controls the overall performance of the controller algorithm. Basically, to adjust the controller response, only the controller speed needs to be changed.

The algorithm is based upon the difference between the setpoint and the measured value (called the error value). The correction signal to eliminate the error is assembled from 3 basic components:

- The P-action (proportional) multiplies the error value by a constant factor, to adjust the measure towards the (new) setpoint.
- The I-action (integral) amplifies the correction signal with a factor depending on the integral of the error value over time.
- The D-action (derivative) reduces the strength of the P-action, to prevent overshoot when the (new) setpoint is reached.

The proportional action is enhanced by one of three additional response factors, depending on the control cycle stage:

- Open from zero: the setpoint is larger than zero and the measured value is below 2% of the full scale range.
- Normal step: the measured value differs more than 2% from the setpoint, typically after changing the setpoint (step).
- Stable situation: the measured value differs less than 2% from the setpoint.

The control characteristics are optimized during production. These parameters should only be changed if absolutely necessary, and only by or under the supervision of trained service personnel.

Controller Speed

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0.2…5	254	114/30	0xF2F0…0xF2F1/62193…62194

This parameter sets the overall controller speed factor for the selected fluid. *Controller speed* is set ex factory between value '0.5' (slow) and '2' (fast). The default value is '1'.

PID-Kp

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…1E+10	167	114/21	0xF2A8…0xF2A9/62121…62122

PID controller proportional action, multiplication factor.

PID-Ti

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…1E+10	168	114/22	0xF2B0…0xF2B1/62129…62130

PID controller integral action in seconds.

PID-Td

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…1E+10	169	114/23	0xF2B8…0xF2B9/62137…62138

PID controller derivative action in seconds. The default value is 0.0.

Open From Zero Response

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	165	114/18	0x0E52/3667

Response factor, applied to proportional action when opening the valve from 0%.
- Default value: 128 (no correction)
- Other values adjust the controller gain (correction signal) as follows: Controller gain = *Controller Speed* * *PID-Kp* * $1.05^{(\text{response factor - 128})}$

Normal Step Response

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	72	114/5	0x0E45/3654

Response factor, applied to proportional action during normal control (at setpoint step).
- Default value: 128 (no correction)
- Other values adjust the controller gain (correction signal) as follows: Controller gain = *Controller Speed* * *PID-Kp* * $1.05^{(\text{response factor - 128})}$

Stable Situation Response

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	141	114/17	0x0E51/3666

Stable situation response, applied when the controller is stable (within a 2% band around the setpoint).
- Default value: 128 (no correction)
- Other values adjust the controller gain (correction signal) as follows: Controller gain = *Controller Speed* * *PID-Kp* * $1.05^{(\text{response factor - 128})}$

6.1.6 Master/slave configuration (FLOW-BUS)

Normally, there is no communication between the instruments in a fieldbus system. The FLOW-BUS protocol, however, provides a feature to set up a master/slave relationship between two instruments. The typical behavior of a slave instrument is to automatically set its own setpoint relative to the output (measurement value) of its master.

The output value of any instrument in a FLOW-BUS network is automatically available to all other instruments without extra wiring. A slave instrument can also be a master to other instruments.

To setup a master/slave relationship between instruments, first determine which instrument should be the master and which should be the slave, then set *Control Mode* of the slave instrument to 'FLOW-BUS Slave' (value 2) or 'FLOW-BUS Analog Slave' (value 13), depending on how the setpoint should be calculated (see parameter *Control Mode*).

The slave instrument polls the output value of its master periodically and uses the slave factor to set its own flow relative to the master's.

To prevent damage to the instruments an/or the system(s) they are connected to, be sure to avoid circular references between devices on the same fieldbus. The FLOW-BUS system does not have a protection mechanism.

Master Node

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	1…128	158	33/14	n/a

Set the master node for the instrument.
Note that this parameter is only effective in a FLOW-BUS network with RS-485 communication.

Slave Factor

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…500	139	33/1	0xA108…0xA109/41225…41226

The controller output from the master instrument is multiplied by *Slave Factor*/100% to get the slave instrument setpoint. In systems other than FLOW-BUS via RS-485, *Slave Factor* is effective only if *Control Mode* is set to 'Analog slave', and the analog output signal of the master instrument is redirected to the input of the slave instrument.

Example:
- master output = 80%
- *Slave Factor* = 50

⇨ slave instrument setpoint = 80% x 50%/100% = 40%

6.1.7 Device identification

User Tag

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[16]	RW	-	115	113/6	0xF130…0xF137/ 61745…61752

With this parameter, the instrument can be given a custom tag name, with a maximum of 16 characters.

Customer Model

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[16]	RW 🔑	-	93	113/4	0xF120…0xF127/ 61729…61736

This parameter is used to add extra information to the model number information, such as a customer-specific model number.

Serial Number

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[20]	R 🔑	-	92	113/3	0xF118…0xF11F/ 61721…61728

Instrument serial number for identification.

BHT Model Number

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[35]	RW 🔑	-	91	113/2	0xF110…0xF117/ 61713…61720

This parameter shows the Bronkhorst® instrument model type information.

Firmware Version

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[6]	R	-	105	113/5	0xF128…0xF12A/ 61737…61739

Revision number of the firmware

Identification Number

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW 🔑	0…255	175	113/12	0x0E2C/3629

Bronkhorst® (digital) device type identification number.

Device Type

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[6]	R	-	90	113/1	0xF108…0xF10A/ 61705…61707

Device type information string; this parameter contains an abbreviation referring to the identification number.

6.1.8 Special parameters

Init Reset

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	82/64	7	0/10	0x000A/11

Init Reset is used to unlock secured parameters (marked with a 🔑 symbol) for writing. It supports the following values:

Value	Description
64	unlocked, secured parameters can be read and written to
82	locked, secured parameters are read-only

At power-up, *Init Reset* is always set to 'Locked' (value 82).

Reset

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	R	0…7	114	115/8	0x0E68/3689

This parameter is used to reset the program, counter or alarms.

Value	Description
0	No reset
1	Reset counter
2	Reset alarm
3	Reset counter
4	Reset and disable counter
5	Reset firmware program (soft reset)
6	Reset *Alarm info* error bit
7	Reset *Alarm info* warning bit

The Reset *parameter may be disabled by* Reset Alarm Enable *or* Reset Counter Enable. *Make sure the value is accepted by sending value 0 first.*

Wink

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char [27]	W	0…9*	1	0/0	0x0000/1

Sending any text string value between 1 and 9 to this parameter makes the indication LEDs (if present) blink for a couple of seconds. This can be useful in order to identify a specific device in a large fieldbus network.

*) Modbus only supports value 14592

Control Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	12	115/1	0x0024/37

Control Mode is used to select different control modes of the instrument and determines from which source(s) it accepts a setpoint. The following control modes are available:

Value	Mode	Instrument action	Setpoint source
0	BUS/RS232	Controlling	Fieldbus/RS-232
1	Analog Input	Controlling	Analog input
2	FLOW-BUS Slave	Acting as slave instrument on FLOW-BUS	RS-485 only: FLOW-BUS master output x *Slave Factor*/100%
3	Valve Close	Controller disabled, valve closed	
4	Controller Idle	Controller disabled, valve frozen in current position	
7	Setpoint 100%	Controlling, setpoint fixed to 100%	
8	Valve Fully Open	Controller disabled, valve fully opened	
9	Calibration Mode	Calibration mode enabled (factory only)	
10	Analog Slave	Acting as slave of other instrument in analog mode	*Analog Input* x *Slave Factor*/100%
12	Setpoint 0%	Controlling, setpoint fixed to 0%	
13	FLOW-BUS Analog Slave	Acting as slave of other instrument on FLOW-BUS, slave factor is set by analog input signal	RS-485 only: FLOW-BUS master output x *Analog Input*
18	RS232	Controlling, safe state deactivated	Fieldbus/RS-232
20	Valve Steering	Controller disabled, setpoint redirected to *Valve output*	
21	Analog Valve Steering	Controller disabled, analog input redirected to *Valve output*	
22	Valve Safe State	Force instrument in safe state	

Immediately after power-up, *Control Mode* is set to 'Analog input' or 'BUS/RS232' automatically, depending on the (requested) default setting for analog or digital operation. If *Control mode* is set to value 0, 1, 9 or 18, the instrument returns to its default control mode at the next power-up or reset. Other values are retained after power-up or reset.

Calibration Mode

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0, 9, 255	58	1/4	0x0E61/3682

After enabling calibration mode by means of parameter *Control Mode*, this parameter is used to start the autozero function of the flow sensor. The following modes are supported:

Value	Description
0	Idle (no action)
9	Start zeroing
255	Error (result of previous calibration mode)

6.1.8.1 Default control mode

IO Status

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…255	86	114/11	0x0E4B/3660

The instrument is set to accept a setpoint from either an analog or a digital source. Although this setting can be changed with parameter *Control Mode*, the instrument usually returns to its default control mode at every power-up or reset. The default control mode can be set with parameter *IO Status*; to change it, use the procedures as described below.

Changing from digital operation to analog operation:
1. Set parameter *Init Reset* to 64 (unlocked)
2. Read parameter *IO Status*
3. Add 64 to the read value
4. Write the new value to parameter *IO Status*
5. Set parameter *Init Reset* to 82 (locked)

Changing from analog operation to digital operation:
1. Set parameter *Init Reset* to 64 (unlocked)
2. Read parameter *IO Status*
3. Subtract 64 from the read value
4. Write the new value to parameter *IO Status*
5. Set parameter *Init Reset* to 82 (locked)

The procedures described above do not change the value of parameter Control Mode *directly. To apply the new default control mode immediately, change the value of parameter* Control Mode *manually or reset or restart the instrument.*

7 Maintenance

Inexpertly servicing instruments can lead to serious personal injury and/or damage to the instrument or the system it is used in. Servicing must therefore be performed by trained and qualified personnel. Contact your Bronkhorst representative for information about cleaning and calibration. Bronkhorst has a trained staff available.

- *Before disconnecting or disassembling any fluid system related parts, always make sure the fluid system is depressurized.*
- *When depressurizing, prevent sudden pressure changes by shutting off the fluid supply gradually.*

In order to prevent clogging and maintain functionality and the specified performance, flushing or purging the fluid system with an appropriate (cleaning) fluid is advised at the following occasions:

- before changing fluid types
- before and after using corrosive, reactive or flammable media
- before and after prolonged shutdown periods*
- every 3 months

In the event of serious contamination, flushing the fluid system may even be necessary to restore the specified system performance.

*) As a rule of thumb a period of a few days to a week can be assumed. In practice, the length of this period strongly depends on the properties of the processed medium and the ambient and process conditions. With some media, leaving the installation unused for longer periods of time without flushing will be no problem, while other fluids will already cause trouble after a very short time of inactivity.

Always use a non-aggressive, non-corrosive cleaning liquid or a dry, inert gas (like Nitrogen or Argon) to flush or purge the fluid system.

Although the ES-FLOW™ has been tested thoroughly at the factory for leaks in the fluid system, environmental influences (such as excessive vibrations and temperature and humidity fluctuations) can cause wear to tubing, piping and fluid connections over time.

Frequent inspection of all fluid lines and connections before, during and after operation is essential, to ensure and maintain a safe working environment. If necessary, re-tighten fluid connections.

7.1 Cleaning

When the measuring tube gets clogged by highly viscous and/or sticky liquids, it can be cleaned manually, using a thin channel cleaning brush before flushing it with a cleaning liquid.

The end user is responsible for validation of the cleaning procedure and results.

7.2 Calibration

The ES-FLOW™ has been factory calibrated. Periodical inspection, recalibration or verification of the accuracy may be subject to individual requirements of the end user.

Bronkhorst certifies that the instrument meets the rated accuracy. Calibration has been performed using measurement standards traceable to the Dutch Metrology Institute (VSL).

8 Troubleshooting and service

Errors and warnings

- *See the troubleshooting guide for general LED indications that signify errors or warnings (red ●) and possible causes.*
- *Most other indications are specific to the installed communication interface; consult the according interface manual for a list of all indications.*
- *Error and warning information can also be found by connecting the instrument to FlowDDE and FlowPlot. FlowDDE puts all errors and warnings on the console screen; FlowPlot provides several specific alarm and counter indicators. See also section Digital communication.*

General problems

- *Electronic problems can be traced by restarting the equipment.*
- *If the equipment starts up normally, the measurement and control behavior can be checked by applying fluid pressure.*
- *To track down problems in the fluid system, depressurize the fluid system and disconnect the suspected unit from the process line. Dirt or clogging might be quickly detected by visual inspection on disassembled fluid connections.*

If you suspect leakage, do not disassemble the device for inspection, but contact your Bronkhorst representative for service or repairs.

8.1 Common issues

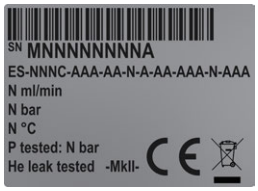
Symptom	Possible cause	Corrective action
No (fieldbus) communication	No power supply	• Check power supply • Check cable connection • Check cable hook-up
	Invalid node address	Change node address (see Network configuration)
	Invalid baud rate	Make sure instrument baud rate matches master/application baud rate
	Other	Reset instrument and/or restart master. If problem persists, contact your Bronkhorst representative
No output signal	No power supply	• Check power supply • Check cable connection • Check cable hook-up
	Invalid control mode (instrument accepts no setpoint)	Check control mode (see Special parameters)
	No setpoint given or setpoint too low	Give setpoint ≥ 2%
	Valve(s) in default state (normally closed)	Check if valves are in default/safe state; solve cause if necessary (see Default valve state)
	Inlet pressure or differential pressure too low	Increase inlet pressure
	Piping, filters and/or control valve clogged or blocked	Clean fluid system (flush with clean, dry air or a non-aggressive cleaning liquid, e.g. ethanol or isopropyl alcohol)
	Sensor failure	Contact your Bronkhorst representative
Mode/MOD and Error/NET LEDs blinking red alternately, no communication	Initialization error	Restart instrument. If problem persists, contact Bronkhorst
Red LED lit continuously, measurement readout irregular	Gas in measuring tube	Fill fluid lines homogeneously with process liquid (see First use)
	Inlet pressure unstable (flow rate pulsating)	Eliminate pressure fluctuations, e.g. by installing a pressure regulator

Symptom	Possible cause	Corrective action
Red LED lit continuously, no flow	Hardware error	Contact your Bronkhorst representative
• Control behavior unstable • Red LED flickering	Measurement disturbed by vibrations	• If possible, avoid installation in close proximity of mechanical vibration • Reduce sensitivity to vibrations by using a mass block, shock absorbers, and flexible tubing
	Inlet pressure unstable	Install pressure regulator or increase buffer volume between controlling instruments
	Inlet and/or outlet pressure too high or too low	Adjust pressure and/or set instrument pressure in accordance with actual process pressure (e.g. with FlowTune™)
	Wrong process gas selected	Select correct process gas (e.g. with FlowTune™)
	Gas accumulation in tubing	Remove gas from liquid tubing (see First use)
	Wrong controller settings	Adjust settings (e.g. with FlowPlot)
	Control valve damaged	Contact your Bronkhorst representative
No flow (sending a setpoint has no effect)	No fluid supply	Check upstream components for obstruction, e.g.: • fluid lines • valves • filters
	Setpoint too low	Give setpoint ≥ 2%
	Actuator cable not connected or damaged	Check actuator cable
	Valve(s) in default state (normally closed)	Check if valves are in default/safe state; solve cause if necessary (see Default valve state)
	Inlet pressure or differential pressure out of bounds	Set inlet pressure to a value within specifications
Flow rate never reaches setpoint	• Piping, filters and/or control valve clogged or blocked • Sensor obstructed or contaminated	Flush fluid system with clean, dry air or non-aggressive cleaning liquid (e.g. ethanol or isopropyl alcohol)
	Inlet pressure or differential pressure too low	• Check/increase inlet pressure • Use instrument in conditions it was designed for
	Outlet pressure too high	• Check/decrease outlet pressure • Use instrument in conditions it was designed for
	Process outlet blocked	Check process outlet and downstream piping
	Process gas condensation	Decrease inlet pressure or increase gas temperature
	Supplied fluid type does not match selected fluid type	Supply equipment with other fluid or change fluid type in instrument configuration
Pressure signal gradually decreasing without setpoint change	Process gas condensation	Decrease inlet pressure or increase gas temperature

Symptom	Possible cause	Corrective action
Measured value or output signal indicates flow, while there should be none	Fluid system leakage	• Check fluid system for leakage • Follow mounting instructions when installing third party components (e.g. adapters, tubing, valves)
	Mounting orientation and/or process conditions changed significantly	• Install instrument according to mounting recommendations • Use instrument in conditions it was designed for • Adjust zero point
	Zero point adjustment performed incorrectly	Readjust zero point, following instructions in Adjusting zero point
Continuous maximum measured value or output signal	Inlet pressure too high	Check inlet pressure
	Valve fully open	• Close valve • In case of normally open valve: check if valve is in safe state; resolve cause if necessary (see Default valve state)
	Sensor failure	Contact your Bronkhorst representative
Fluid system leakage	Bad connection between parts (e.g. ferrules, nuts, tubing, piping, valves)	Follow mounting instructions issued by third party components (e.g. adapters, tubing, valves)

8.2 Service

If you have questions about a product or if you find the product does not meet the specifications as ordered, do not hesitate to contact your Bronkhorst representative. To enable us to help you quickly and effectively, make sure to have the serial number ready whenever seeking contact with your Bronkhorst representative about a specific item. The serial number (SN; first line on the serial number label) is the key to the original purchase order and can be found on the product.



For current information about Bronkhorst® and service addresses, please visit our website:

www.bronkhorst.com

Do you have any questions about our products? Our Sales Department will gladly assist you selecting the right product for your application. Contact sales by e-mail:

sales@bronkhorst.com

For after-sales questions, our Customer Service Department is available with help and guidance. To contact CSD by e-mail:

aftersales@bronkhorst.com

No matter the time zone, our experts within the Support Group are available to answer your request immediately or ensure appropriate further action. Our experts can be reached at:

+31 859 02 18 66

Bronkhorst High-Tech B.V.
Nijverheidsstraat 1A
NL-7261 AK Ruurlo
The Netherlands

9 Returns

9.1 Removal and return instructions

When returning materials, always clearly describe the problem, and, if possible, the work to be done, in a covering letter.

Instrument handling:

1. Purge all fluid lines (if applicable)
2. If the instrument has been used with toxic or otherwise hazardous fluids, it must be cleaned before shipping
3. Disconnect all external cabling and tubing and remove the instrument from the process line
4. If applicable, secure movable parts with appropriate transport safety materials, to prevent damage during transportation
5. The instrument must be at ambient temperature before packaging
6. Insert the instrument into a plastic bag and seal the bag
7. Place the bag in an appropriate shipping container; if possible, use the original packaging box

Add documentation:

- Reason of return
- Failure symptoms
- Contaminated condition
- Declaration on decontamination

It is absolutely required to notify the factory if toxic or dangerous fluids have been in contact with the device!
This is to enable the factory to take sufficient precautionary measures to safeguard the staff in their repair department.

All instruments must be dispatched with a completely filled in 'Declaration on decontamination'. Instruments without this declaration will not be accepted.

*A safety information document containing a 'Declaration on decontamination' form (document no 9.17.032) can be downloaded from the **Service & Support** section of the Bronkhorst website (**www.bronkhorst.com**).*

Important:
Clearly note, on top of the package, the customs clearance number of Bronkhorst High-Tech B.V.:

NL801989978B01

(only if applicable, otherwise contact your Bronkhorst representative for local arrangements.)

9.2 Disposal (end of lifetime)

Within the European Union, manufacturers of electrical and electronic equipment (EEE) are obliged to comply with the WEEE directive (waste electrical and electronic equipment). Bronkhorst offers its customers the possibility to return EEE for disposal at the end of its life, so that it can be properly dismantled and the components recycled or, if possible, reused.

All Bronkhorst® products covered by the WEEE directive (the majority) carry an image of a crossed-out waste bin (usually on the serial number label). If you wish to dispose of Bronkhorst® equipment bearing this symbol, simply return it in accordance with the removal and return instructions, and Bronkhorst will take care of proper dismantling, recycling and/or reuse (wherever possible). In the covering letter, just mention that you are returning the product for disposal. Within the EU, returning products for disposal is of course free of charge (except for shipping and handling costs).

In countries outside the EU, EEE disposal may be subject to local or national directives and/or legislation. If applicable, consult local or national authorities to learn how to handle EEE properly in your area.

Parameter index

Parameters