Instruction Manual

mini CORI-FLOW™ M1x series

Compact Coriolis Mass Flow Meters/Controllers for Liquids and Gases

Doc. no.: 9.17.050 rev. L Date: 17-12-2019

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 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 Bronkhorst representative.

Receipt of equipment

Check the outside packaging box for damage incurred during shipment. If the box is damaged, then the local carrier must be notified at once regarding his liability, if so required. At the same time a report should be submitted to your Bronkhorst representative.

Carefully remove the equipment from the box. Verify that the contents of the package was not damaged during shipment. Should the equipment be damaged, then the local carrier must be notified at once 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 of the items included in the scope of delivery*
- *Do not discard spare or replacement parts with the packaging material*

Refer to Removal and return instructions about return shipment procedures.

Equipment storage

The equipment should be stored in its original package in a cupboard warehouse or similar. Care should be taken not to subject the equipment to excessive temperatures or humidity.

Warranty

Bronkhorst® products are warranted against defects in material and workmanship for a period of three years from the date of shipment, 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 this period may be repaired or replaced at no charge. Repairs are normally warranted for one year or the balance of the original warranty, whichever is the longer.

See also section 9 (Guarantee) of the Conditions of sales:
www.bronkhorst.com/int/about/conditions-of-sales/

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. The costs of unstamped returns are added to the repair invoice. Import and/or export charges as well as costs of foreign shipping methods and/or carriers are paid by the customer.

General safety precautions

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Before operating, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables for cracks or breaks before each use.

The equipment and accessories must be used in accordance with their specifications and operating instructions, otherwise the safety of the equipment may be impaired.

If required, replace fuses with the same type and rating for continued protection against fire hazard.

Opening the equipment is not allowed. There are no user serviceable parts inside. In case of a defect please return the equipment to Bronkhorst High-Tech B.V.

One or more warning signs may be present on different parts of the product. These signs have the following meaning:

Consult the instruction manual for handling instructions

Surface may get hot during operation

Shock hazard; electrical parts inside

To maintain protection from electric shock and fire, replacement components must be obtained from Bronkhorst. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be obtained from other suppliers, as long as they are equivalent to the original component. Selected parts should be obtained only through Bronkhorst, to maintain accuracy and functionality of the product. If you are unsure about the relevance of a replacement component, contact your Bronkhorst representative for information.

Table of contents

1 Introduction

1.1 Scope of this manual

This manual contains general product information, installation and operating instructions and troubleshooting tips for the **mini CORI-FLOW™ M1x** series mass flow meters and controllers for liquids and gases.

1.2 Intended use

The Bronkhorst® **mini CORI-FLOW™ M1x** is an accurate mass-flow meter/controller for measuring and controlling gas and liquid flows at pressures up to 200 bar(a), virtually independent of pressure and temperature changes. A wide range of liquids and gases can be measured independent of fluid density, temperature and viscosity.

The wetted materials incorporated in the mini CORI-FLOW are compatible with media and conditions (e.g. pressure, temperature) as specified at ordering time. If you are planning to use the product (including any third party components supplied by Bronkhorst, such as pumps or valves) with other media and/or other conditions, always check the wetted materials (including seals) for compatibility. See the technical specifications of the product and consult third party documentation (if applicable) to check the incorporated materials.

Responsibility for the use of the equipment with regard to suitability, intended use, cleaning and corrosion resistance of the applied materials against the processed media lies solely with the end user.

Where appropriate, this document recommends or prescribes safety measures to be taken with respect to media usage or working with the described equipment 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 end user is considered to be familiar with the necessary safety precautions, and to comply with the appropriate protective measures as described in the Material Safety Data Sheets of the media to be used in the system (if applicable).

Bronkhorst High-Tech B.V. cannot be held liable for any damage resulting from improper or unsafe use, use for other than the intended purpose or use with other media and/or under other conditions than specified on the purchase order.

1.3 Product description

mini CORI-FLOW™ M1x instruments are precise and compact mass flow meters and controllers for liquids and gases, based on the Coriolis measuring principle. Designed to cover the needs of the low flow market, there are 4 models, supporting flow ranges from 5 g/h up to 300 kg/h (full scale values), each offering multi-range functionality: factory calibrated measuring ranges can be re-scaled by the user, without affecting the original accuracy specifications. The instruments are built into a robust, weatherproof housing, with a high ingress protection rating.

The **mini CORI-FLOW** measures real mass flow, regardless of the media properties. The system can be complemented with a (modular or integrated) control valve or a pump and a readout and control unit to measure and control gas and liquid flows.

Measuring principle
Instruments of the **mini CORI-FLOW** series contain a uniquely shaped, single loop sensor tube, forming part of an oscillating system. When a fluid flows through the tube, the Coriolis force causes a phase shift, which is detected by sensors and fed into the integrated printed circuit board. The resulting output signal is proportional to the real mass flow rate, independent of fluid density, temperature, viscosity, pressure, heat capacity or conductivity. Coriolis mass flow measurement is fast, accurate and inherently bi-directional. The **mini CORI-FLOW™ M1x** features density and temperature of the fluid as secondary outputs.

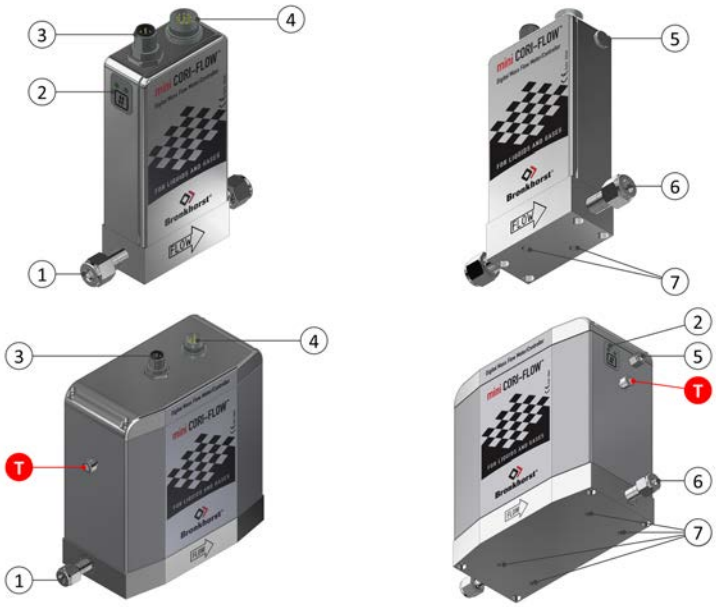
Multi-range
The **mini CORI-FLOW** offers multi-range functionality: factory calibrated ranges can be re-ranged to a different full scale measuring range (e..g. a mini CORI-FLOW model M13 can be used for full scale ranges between 50 g/h and 2000 g/h). The analog output and the digital measured value are scaled accordingly.

Switching between ranges can be done via the RS232 interface or the fieldbus interface, or with a Bronkhorst® readout and control unit (E-8000, BRIGHT). For RS232 communication, Bronkhorst can offer a special T-part RS232 cable to connect the instrument with a Windows computer, together with free tooling software (FlowPlot). Contact your Bronkhorst representative for more information.

The instrument comes with a calibration certificate for all supported full scale ranges. The actual full scale of the instrument is set to a value as ordered and can be found on the instrument label.

Accuracy
The accuracy of a **mini CORI-FLOW** series instrument is either 0.2% reading for liquids or 0.5% reading for gases, based on mass flow (e.g. g/h, kg/h, etc.). Using the instrument for measuring volume flows (e.g. l/h, ml/min) will introduce an additional inaccuracy, based on the actual density measured by the instrument.

1.4 Product overview



1. Fluid inlet (fitting type may differ, depending on ordering details)
2. Manual control interface
3. Fieldbus connection (optional)
4. Power supply/analog interface/RS232 connection
5. Actuator output (optional)
6. Fluid outlet
7. Mounting holes

T. Transportation bolts (model M15 only)

Transportation bolts - important notes:
- *Upon delivery, the moving parts of the M15 are immobilized with 2 transportation bolts, to prevent damage to the sensor during transportation and handling.*
- *Before installing the M15, the transportation bolts must be removed.*
- *Carefully follow the instructions on the leaflet that is attached to the M15.*
- *Do not discard the transportation bolts, but keep them for future use.*
- *Before transporting the equipment, (e.g. for relocation or servicing), the transportation bolts must be re-installed.*

1.5 Calibration

The mini CORI-FLOW is 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).

Unless specified otherwise, mini CORI-FLOW™ M1x instruments are H_20 calibrated.

1.6 Maintenance

The mini CORI-FLOW needs no regular maintenance if operated properly, with clean media, compatible with the wetted materials, avoiding pressure and thermal shocks and vibrations. Units may be purged with a clean, dry and inert gas or a non-aggressive and non-corrosive solvent.

In case of severe contamination, cleaning of the inside of the instrument and of the valve orifice (if applicable) may be required.

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.

1.7 Documentation

The mini CORI-FLOW comes with all necessary documentation for basic operation and maintenance. Some parts of this manual refer to other documents, most of which can be downloaded from the Bronkhorst website.

*The documentation listed in the following table is available on the **mini CORI-FLOW** product pages under **www.bronkhorst.com/products***

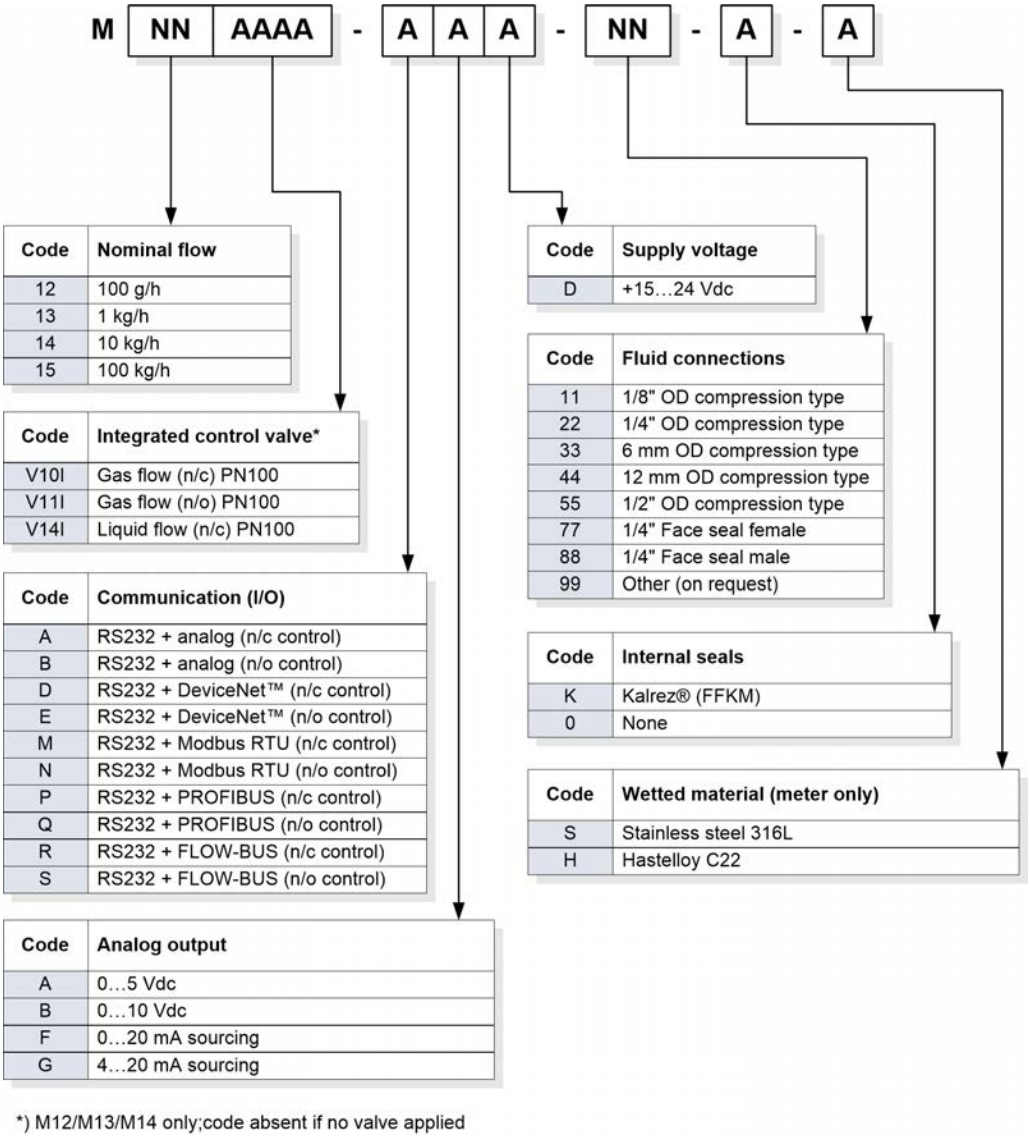
Type	Document name	Document no.
Manuals	Instruction Manual mini CORI-FLOW™ M1x (this document)	9.17.050
	Quick Installation Guide mini CORI-FLOW	9.17.052
Technical documentation	Hook-up diagram Analog/RS232	9.16.044
	Hook-up diagram DeviceNet™	9.16.050
	Hook-up diagram FLOW-BUS	9.16.048
	Hook-up diagram Modbus	9.16.066
	Hook-up diagram PROFIBUS DP	9.16.049
	Dimensional drawings	model specific

*The documentation listed in the following table can be downloaded from **www.bronkhorst.com/downloads/***

Type	Document	Document no.
General documentation	EU Declaration of Conformity	9.06.021
Manuals	Manual DeviceNet™ interface	9.17.026
	Manual EtherCAT® interface	9.17.063
	Manual FLOW-BUS interface	9.17.024
	Manual Modbus interface	9.17.035
	Manual PROFIBUS DP interface	9.17.025
	Manual PROFINET interface	9.17.095
	Manual RS232 interface	9.17.027

1.8 Model key

The model key on the product label contains information about the technical properties of the instrument as ordered. The specific properties can be retrieved with the diagram below.



Code	Nominal flow
12	100 g/h
13	1 kg/h
14	10 kg/h
15	100 kg/h

Code	Integrated control valve*
V10I	Gas flow (n/c) PN100
V11I	Gas flow (n/o) PN100
V14I	Liquid flow (n/c) PN100

Code	Communication (I/O)
A	RS232 + analog (n/c control)
B	RS232 + analog (n/o control)
D	RS232 + DeviceNet™ (n/c control)
E	RS232 + DeviceNet™ (n/o control)
M	RS232 + Modbus RTU (n/c control)
N	RS232 + Modbus RTU (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)

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

*) M12/M13/M14 only;code absent if no valve applied

Code	Supply voltage
D	+15…24 Vdc

Code	Fluid connections
11	1/8" OD compression type
22	1/4" OD compression type
33	6 mm OD compression type
44	12 mm OD compression type
55	1/2" OD compression type
77	1/4" Face seal female
88	1/4" Face seal male
99	Other (on request)

Code	Internal seals
K	Kalrez® (FFKM)
0	None

Code	Wetted material (meter only)
S	Stainless steel 316L
H	Hastelloy C22

2 Installation

2.1 Functional properties

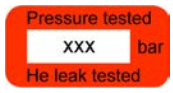
Before installing the mini CORI-FLOW, check the serial number label on the instrument to see if the functional properties match your requirements:

- Flow rate
- Media to be used in the instrument
- Upstream and downstream pressure(s)
- Operating temperature
- Valve type (if applicable; N.O. = Normally Open, N.C. = Normally Closed)
- Technical properties (see Model key)

2.2 Operating conditions

Test pressure

*Bronkhorst® instruments are pressure tested to at least 1.5 times the specified operating pressure and outboard leak tested to at least 2 * 10^{-9} mbar l/s Helium.*
The operating pressure must never exceed the test pressure.



- *The test pressure is specified on the device with a red label; if this label is missing or if the test pressure is insufficient, the device must not be used and should be returned to the factory.*
- *Before installation, make sure that the test pressure is in accordance with the safety factor of your application.*
- *Disassembling the device and/or replacing parts will invalidate the test pressure and leak test specification.*

Sealing material compatibility

mini CORI-FLOW instruments with an integrated control valve are fitted with specific sealing material(s), compatible with the media specified at ordering time. Be sure that the sealing materials are compatible with the media and conditions used in the system. Bronkhorst High-Tech B.V. cannot be held responsible for any damage resulting from the use of other media and/or conditions than specified on the purchase order.

2.3 Mounting

For optimal performance, installation in a vibration free position is essential. Use the mounting holes in the bottom of the instrument body (see product overview) to fixate the instrument to a firm, rigid base or heavy, vibration free mass, such as a wall, a heavy rig or another stable construction. If such a facility is not available, use the supplied mounting block. This mounting block has a mass and stiffness precisely tuned for the specific mini CORI-FLOW model and can be used as a base. Contact your local Bronkhorst representative for more information.

- *Always use the mounting holes to fixate the instrument. Check the dimensional drawing for the exact locations and size of the mounting holes.*
- *Also make sure that the instrument is not suspended by the piping and take adequate measures to isolate the instrument from vibrations in the piping.*

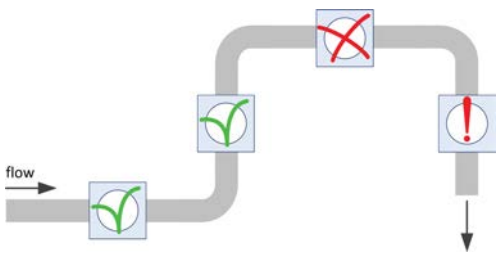
2.3.1 Orientation

Generally, the reliability of a mini CORI-FLOW instrument is not affected by the mounting orientation.

2.3.2 Location

For **gas applications**, mount the instrument in a location where condensate (if any) cannot accumulate inside the instrument's media conduits.

In **liquid applications**, the presence of gas bubbles in the liquid can cause measuring errors. In general, the instrument should be mounted in a pipe segment where gas bubbles (if any) cannot accumulate. The image to the right shows the preferable mounting locations.

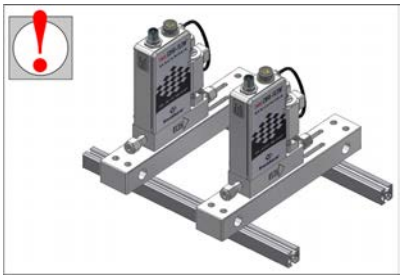


- The best location is a horizontal pipe segment or a segment where the fluid direction is upward.
- Gas might accumulate in a horizontal segment if it is followed by a downward segment. Do NOT mount the instrument in a location like this.
- Mounting in a downward pipe segment with an open end is strongly 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 more problematic.

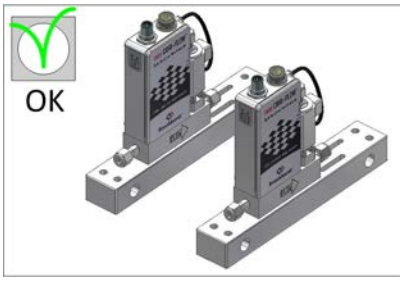
To minimize the risk of gas entrapment by cavitation, the preferred location to install a control valve is downstream from the instrument, for a pump the preferred location is upstream.

2.3.3 Preventing resonance

If multiple mini CORI-FLOW™ M1x instruments will be used in the same fluid system, observe the following guidelines:



Vibrations from the environment or from one instrument might interfere with the resonance frequency of another instrument



To minimize resonance, isolate instruments mechanically by mounting them on individual rigid, stiff mounting blocks. Preferably, mount multiple instruments parallel to each other, and use flexible piping.

Mass blocks can be isolated mechanically with (silicon) rubber suspension pads. Mounting blocks and suspension pads can be obtained via your local Bronkhorst representative.

2.3.4 Fluid connections

Flow direction

- Install the mini CORI-FLOW in the process line, in accordance with the direction of the FLOW arrow on the base of the instrument.
- Tighten connections according to the instructions of the supplier of the fittings.

Fittings

Typically, Bronkhorst® mini CORI-FLOW meters/controllers are fitted with compression or face-seal-fittings.
For leak tight installation of compression type fittings, make sure that the tube is inserted to the shoulder in the fitting body and tube, ferrules and fittings are free of dirt or other particles. Tighten the nut finger-tight while holding the instrument, then tighten the nut 1 turn.

If applicable follow the guidelines of the supplier of the fittings. Special fitting types are available on request.

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

After using the mini CORI-FLOW for the first time with low temperature media, re-tighten the fluid connections, in order to prevent leakage.

2.3.5 Piping requirements

During the manufacturing process, the instrument has been tested with water. Despite the fact that it has been purged thoroughly afterward, the instrument cannot be guaranteed to be absolutely free of water droplets upon delivery. For applications where remaining water particles might cause undesired reactions, such as corrosion, Bronkhorst strongly recommends performing an additional, adequate drying procedure.

- *Select piping or tubing that is suitable for the operating conditions (media, maximum temperature, maximum operating pressure) of the application.*
- *Do not install small diameter piping/tubing on high flow rates and avoid abrupt angles or other disturbances within a distance of 10 times the (inside) pipe diameter from the inlet or outlet of the device.*
- *Do not install pressure regulators within a distance of 25 times the (inside) pipe diameter.*

2.4 Preventing pressure shocks

mini CORI-FLOW instruments handle pressure shocks in the system well, but are not insensitive to pressure fluctuations. For optimal control stability, observe the following guidelines:

- *Provide a stable (pressure controlled) inlet pressure; put sufficient buffer volume between the pressure regulator and the instrument. As a rule of thumb, install pressure regulators at a distance of at least 25 times the pipe diameter from the inlet or outlet of the instrument.*
- *When using multiple instruments and/or control valves, prevent interference by putting piping with sufficient buffer volume between components*
- *Avoid installing multiple instruments or control valves in close proximity to another*

2.5 Preventing hydraulic shocks

In a fluid system where fluid movement (liquid or gas) is forced to stop or start suddenly (by a pump or a shut-off valve), a hydraulic shock (or fluid hammer) can occur, especially if the fluid velocity is high. This momentum change causes a pressure surge (spike) traveling repeatedly from one end of the piping to the other. Rapid pressure fluctuations like this can cause leakage and damage to fluid lines and components, and ultimately damage to the instrument.

The following measures can be taken to prevent or minimize hydraulic shocks:

- *Avoid abrupt fluid acceleration and deceleration*
  - *Avoid large pipe diameter transitions by using piping and tubing with an inside diameter that matches that of the instrument as closely as possible*
  - *Keep the fluid velocity through the instrument as small as possible*
- *Install an accumulator to dampen acceleration and deceleration of the fluid flow*

Consult your Bronkhorst representative if you need more information about prevention of hydraulic shocks.

2.6 Electrical connection

Electrical connections must be made with standard cables or according to the applicable hook-up diagrams. Make sure that the power supply is suitable for the power ratings as indicated on the serial number label (see model key), and that double or reinforced insulation is used for the power supply cabling. For use in fieldbus systems, follow the instructions of the cable supplier for the specific fieldbus system.

*The device 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 device carries the CE-mark and is **compliant with the concerning EMC requirements**. However, compliance with the EMC requirements is not possible without the use of proper 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 in doubt, contact your Bronkhorst representative.*

*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.***

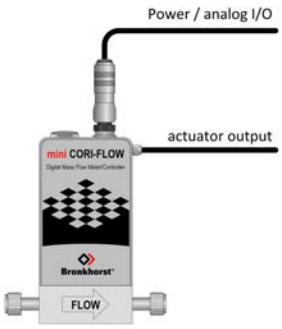
***Never** power the instrument simultaneously from **two different power sources** (e.g. fieldbus and Plug-in Power Supply). Doing so will damage the printed circuit board irreparably.*

Always isolate the electrical power before connecting or disconnecting equipment.

2.6.1 Analog or local connection

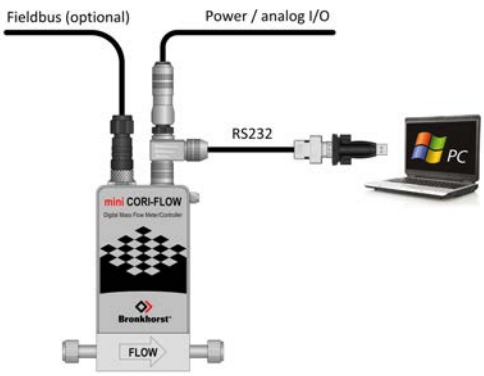
Connect the mini CORI-FLOW to the power supply/readout unit using a cable with an 8-pin female connector on the instrument side. Refer to the hook-up diagram for analog operation to connect the required signals.

For controllers, the control valve or pump is typically powered separately via the actuator output.

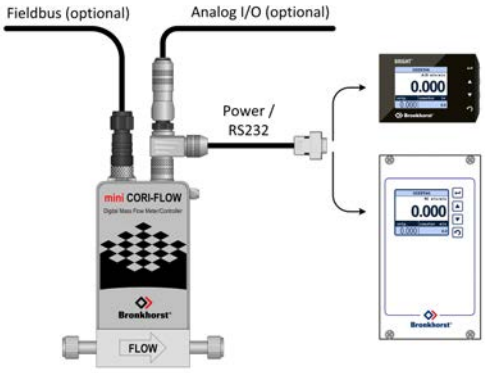


2.6.2 Digital RS232 connection

Using a special T-part RS232 cable, the 8-pin DIN connector of the instrument can be connected to a COM port or a USB port (via an RS232/USB converter) of a Windows computer. Power can be supplied by a Plug-in Power Supply (PiPS) or via the optional fieldbus connection (FLOW-BUS, Modbus, DeviceNet™).



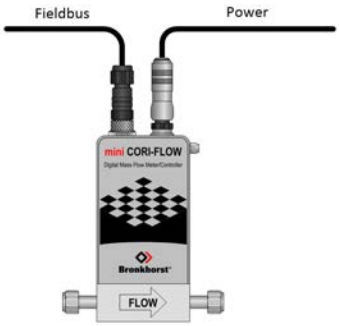
Alternatively, connect the instrument to a Bronkhorst® readout and control unit (BRIGHT/E-8000). In this case, the instrument can also be powered through the readout and control unit. With the display interface and control buttons most digital parameters and functions can be used.



For RS232 communication with a third party micro controller device (e.g. a PLC, refer to the hook-up diagram for RS232 operation to connect the required signals).

2.6.3 Digital RS485 connection (fieldbus)

If the instrument is provided with a dedicated fieldbus interface, it can be operated digitally in a fieldbus system, using RS485 communication. In FLOW-BUS, Modbus and DeviceNet™ systems, the fieldbus connector (5-pin M12) can also be used to power the instrument. In PROFIBUS DP systems, the instrument is always powered through the 8-pin DIN power connector.



***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.*

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.

If you need assistance with setting up a fieldbus configuration, contact your Bronkhorst representative for information.

2.6.3.1 FLOW-BUS

FLOW-BUS is a Bronkhorst® designed fieldbus, based on RS485 technology, for digital communication between devices, offering the possibility of host-control by a Windows computer.

Characteristics:
- Baud rate 187500 (default) or 400000 Baud
- +15…24 Vdc supply voltage
- Easy installation and communication with other Bronkhorst® devices
- Automatic node search and bus optimization (gap fixing)
- RS232 communication (ProPar) with Windows computer (local host)
- Connection of up to 120 instruments on a single bus
- Maximum bus length: 600 m

*Consult **Instruction manual FLOW-BUS interface** (document no. 9.17.024) for more information about setting up a FLOW-BUS network.*

Power the instruments in a FLOW-BUS local-host system by hooking-up the power supply directly on the FLOW-BUS line and not by powering a set of instruments through the 8-pin DIN connector on one of the digital instruments.

2.6.3.2 Modbus

Modbus is a 3-wire, RS485-based fieldbus communication system for parameter value exchange. In this system each instrument/device is equipped with a micro-controller for its own dedicated task. The instrument behaves as a slave, which means all communication (instructions and readout) is initiated by a master device on the Modbus system.

Characteristics:
- Baud rate selectable between 9600 and 256000 Baud (default: 19200 Baud)
- +15…24 Vdc supply voltage
- Connection of up to 247 instruments on a single bus
- Supports RTU and ASCII protocols

*Consult **Instruction manual Modbus interface** (document no. 9.17.035) for more information about setting up a Modbus network.*

*Detailed information about Modbus can be found at **www.modbus.org/** or any website of the (local) Modbus organization of your country (if available).*

2.6.3.3 PROFIBUS DP

PROFIBUS DP is a 2-wire, RS485-based industrial data communication standard (fieldbus) which allows automation components (e.g. sensors, actuators and controllers) to exchange information.

*Consult **Instruction manual PROFIBUS DP interface** (document no. 9.17.025) for more information about setting up a PROFIBUS DP network.*

2.6.3.4 DeviceNet™

The DeviceNet™ interface offers a direct connection to a DeviceNet™ network, according to the mass flow controller profile specified by the ODVA. The Bronkhorst® DeviceNet™ instrument is a Group 2 Only Server device whose messages comply with the Controlled Area Network (CAN) 2.0A standard and with the DeviceNet™ protocol.

*Consult **Instruction manual DeviceNet™ interface** (document no. 9.17.026) for more information about setting up a DeviceNet™ network.*

3 Operation

After correct installation of the **mini CORI-FLOW™ M1x** Mass Flow Meter (MFM) or Mass Flow Controller (MFC), and when all safety precautions have been taken into account, the instrument can be used for measuring/ controlling the required flow rate in the system.

3.1 Powering up and powering down

- *It is recommended to turn on power before applying fluid pressure and to switch off power only after relieving fluid pressure.*
- *For best performance, allow the device to warm up and stabilize for at least 30 minutes before starting measurement and/or control. This may be done with or without media flow.*

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

3.2 First use

Adequate mass flow measurement is only possible if the fluid flows through the instrument in a single state (either gas or liquid). To prevent 'slug flow' (two-phase flow) at start-up, take the following measures before starting measurement and control:

- *for liquid applications, expel gas from the system, by flushing the instrument and all fluid lines with the process fluid at a relatively high flow rate*
- *for gas applications, expel condensation from the system, by purging the instrument and all fluid lines with a dry gas at a relatively high flow rate*

In systems for use with corrosive or reactive media, purging for at least 30 minutes with a dry, inert gas (like Nitrogen or Argon) is absolutely necessary before use. After use with corrosive, reactive or hazardous media (e.g. toxic or flammable), purging is also necessary before the fluid system is exposed to air.

The very first time the instrument is used, adjusting the zero point is recommended. See Adjusting zero point for background information and instructions.

3.3 Valve Safe State

When a controlling instrument is not powered, the control valve automatically returns to its default state (also called Safe State), which is closed for a 'normally closed' valve (n/c) and fully open for a 'normally open' valve (n/o). To protect the system, certain events (such as communication errors) may cause the instrument to switch to Valve Safe State (see also LED indications).

Check the serial number label or the technical specifications to see which valve type is used on your instrument (if applicable).

3.4 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).

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.

3.5 Temperature considerations

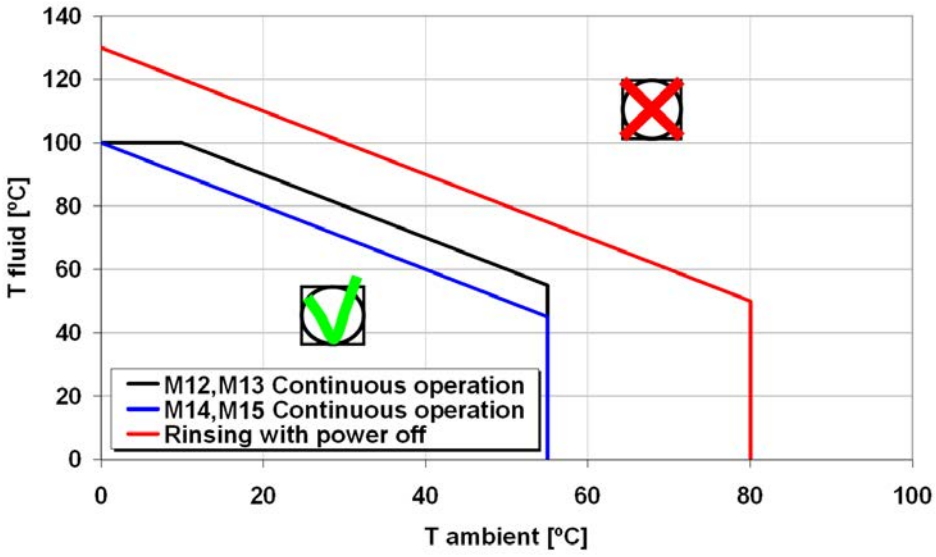
Although the mini CORI-FLOW has excellent temperature stability, the best accuracy is achieved when temperature gradients within and across the instrument are avoided. Take the following guidelines into account:

- *To avoid simultaneous heating and cooling of different parts of the instrument, make sure the ambient temperature is as stable and evenly distributed across the environment as possible.*
- *Avoid temperature shocks; heating or cooling should amount to no more than 1 °C per second.*
- *Make sure that the media temperature matches the ambient temperature as closely as possible.*
- *The mini CORI-FLOW will show an amount of self heating, due to power dissipation of the electronics. This effect can be as large as approximately 15 °C (depending on media and ambient temperature). In practice, there will be a balance between media temperature, self heating and ambient temperature.*
- *Operation in a cool environment can compensate somewhat for the effect of high media temperatures.*
- *Heating and cooling effects will also depend on the cooling/heat conducting capacities of the installation itself on which the instrument is mounted.*

- *To prevent damage to the electronics, make sure the temperature in the housing never exceeds 70°C. To monitor this, the internal temperature reading can be used (parameter Temperature).*
- *The storage temperature should lie between -30 and 80 °C. Make sure the measuring tube is purged and dry before storing the instrument.*

Temperature build-up

The temperature in the instrument housing is largely determined by the media temperature (T fluid) and the ambient temperature (T ambient). Although these temperatures cannot simply be added up to calculate the internal temperature, they do amplify each other. Taking the self heating effect of the electronics into account, some rules of thumb can be defined for the maximum temperatures and their sum to observe. The graph below illustrates these; the area below each line represents the safe temperatures for the according instruments or circumstances.



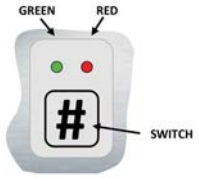
The following rules can be inferred from this graph:

With normal, continuous operation:
- M12, M13: T fluid + T ambient should remain lower than 110 °C
- M14, M15: T fluid + T ambient should remain lower than 100 °C
- T fluid should lie between 0 and 100 °C
- T ambient should lie between 0 and 55 °C

When cleaning (without electrical power to the instrument):
- T fluid + T ambient should remain lower than 130°C
- T fluid should lie between 0 and 130 °C
- T ambient should lie between 0 and 80 °C

3.6 Manual controls

The instrument is equipped with two LEDs and a push button switch, which can be used to monitor the instrument visually and start several functions manually.



3.6.1 LED indications

- (green) Mode: operation mode indication
- (red) Error: error/warning messages

The tables below list the different LED indications:

Green		
Pattern	**Time**	**Indication**
off	continuous	Power-off
on	continuous	Normal operation mode
short flash	0.1 sec on, 2 sec off	Initialization mode
blink	0.2 sec on, 0.2 sec off	Special function mode; the instrument is busy performing a special function (e.g. auto-zero or self-test)
long flash	2 sec on, 0.1 sec off	**DeviceNet™** Idle state **Other protocols** n/a

Red		
Pattern	**Time**	**Indication**
off	continuous	No error
on	continuous	Liquid application: measuring error (no liquid in measuring tube); flush instrument to remove gas **OR** Critical error; the instrument needs servicing before it can be used
short flash	0.1 sec on, 2 sec off	**FLOW-BUS** Node occupied: re-install instrument **PROFIBUS DP** No data exchange between master and slave (automatic recovery) **Modbus** Data is being received or transmitted **DeviceNet™** Minor communication error
blink	0.2 sec on, 0.2 sec off	**FLOW-BUS** Waiting for communication, check communication settings of all FLOW-BUS devices in the fieldbus setup. Usually the 'last node address' setting of one of the devices is incorrect. **DeviceNet™** No bus power **Other protocols** n/a
long flash	2 sec on, 0.1 sec off	**PROFIBUS DP** Requested parameter not available **DeviceNet™** Serious communication error; manual intervention needed **Other protocols** n/a

● Green and ● red (alternating)		
Pattern	**Time**	**Indication**
slow wink	1 sec on, 1 sec off	Alarm indication; minimum/maximum alarm, power-up alarm, limit reached or batch size reached
normal wink	0.2 sec on, 0.2 sec off	Wink mode; by sending a command to the *Wink* parameter, the instrument flashes its LEDs to indicate its physical location
fast wink	0.1 sec on, 0.1 sec off	Selected action started (after releasing the multifunctional switch)

3.6.2 Multifunctional switch

Some special functions of the instrument 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.

3.6.2.1 Normal operating functions

- In order to access these functions, press and hold the switch while the instrument is in normal operation mode (green LED glowing).
- As long as the switch is held, the LEDs show a repeating sequence of patterns, where each pattern indicates a function.
- All indications in this sequence are continuous.
- Each pattern is shown for a number of seconds; in the table below the column *Hold time* indicates the time frame within the sequence where the LEDs show the associated pattern.
- 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	Reset alarm
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)
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. Never perform a zeroing procedure before having taken notice of the instructions.

3.6.2.2 Power-up functions

- In order to access these functions, press and hold the switch while powering up the instrument.
- As long as the switch is held, the LEDs show a repeating sequence of patterns, where each pattern indicates a function.
- All indications in this sequence are flashing (0.2 sec on, 0.2 sec off).
- Each pattern is shown for a number of seconds; in the table below the column *Hold time* indicates the time frame within the sequence where the LEDs show the associated pattern.
- 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…4 sec	No action
off	on	4…8 sec	Restore factory settings (except communication settings)
on	off	8…12 sec	FLOW-BUS: Auto install to bus; let the instrument obtain a free node address from the FLOW-BUS system
on	on	12…16 sec	Activate configuration mode • The 8-pin DIN connector is set to RS232 communication (ProPar) at baud rate 38400 • In configuration mode, the green LED blinks (2 seconds on, 0.1 second off) • Configuration mode remains active after powering-down and can be deactivated by selecting this function again at the next start-up

3.6.2.3 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 to analog or digital, depending on the selected value for parameter Control mode *(contrary to changing the control mode digitally). See Default control mode for information about setting the default control mode.*

3.6.2.4 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	PROFIBUS DP	DeviceNet™
0			automatically detected	
1	187500	9600	9600	125000
2	400000	19200	19200	250000
3		38400	45450	500000
4		56000	93750	
5		57600	187500	
6		115200	500000	
7		128000	1500000	
8		256000	3000000	
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 of the instrument can be changed (non-Ethernet based protocols only; for Ethernet based protocols (EtherCAT®, PROFINET), 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 (green, red or both; 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 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 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 canceled and the instrument returns to its normal operation mode.

3.7 Communication modes

The following table lists the communication modes the mini CORI-FLOW supports:

Connection	Type	Communication standard	Fieldbus/protocol
8-pin DIN male	Analog	0…5Vdc 0…10Vdc 0…20mA 4…20mA	n/a
	Digital	RS232	ProPar
Fieldbus specific	Digital	RS485	FLOW-BUS Modbus RTU PROFIBUS DP DeviceNet™

The communication standards (analog and digital) and fieldbus interface (if applicable) are specified at ordering time, i.e.:
- o *In analog mode, the instrument is set to the specified voltage/current range*
- o *The dedicated fieldbus connection only provides the specified fieldbus interface*

Using analog and digital interfaces simultaneously

The instrument can be operated via the analog and a digital interface at the same time; analog signals and digital parameters can be read (or changed) simultaneously. The instrument accepts a setpoint from either the analog or the digital interface (this is called the control mode; see Special parameters for more information). In analog mode, the analog input and output signals are translated to the digital setpoint and measure parameter respectively. The default control mode (analog or digital) is determined at ordering time.

3.7.1 Analog operation

With analog operation the following parameters are available:

- output signal: measured value (voltage or amperage)
- input signal: setpoint (voltage or amperage; controller only)
- valve voltage (controller only)

Setpoints below 2% of the full scale will be interpreted as 0%.

3.7.2 Digital RS232 operation

Digital operation via RS232 or fieldbus (RS485) adds extra features to the instrument, such as:

- Direct reading with a readout/control module or host computer
- Diagnostics
- Device identification
- Adjustable minimum and maximum alarm limits (Alarms)
- (Batch) counter (Counter)

Make sure in FlowDDE the correct port and baud rate are selected. For RS232 operation the baud rate must be 38400 Baud.

3.7.2.1 FlowDDE

Digital Bronkhorst® instruments can be operated via RS232 using the Bronkhorst® FlowDDE server application. Dynamic Data Exchange (DDE) provides a basic level of inter process communication between Windows applications. Together with a client application, either self-made or with a third party SCADA program, it is possible to create an easy way of data exchange between the flow meter/controller and a Windows application. For instance, a cell in a Microsoft Excel spreadsheet can be linked to the measured value of an instrument; FlowDDE updates the cell automatically when the measured value changes.

FlowDDE uses specific parameter numbers for communicating with the instrument. A DDE parameter number is a unique number in a special FlowDDE instruments/parameter database and not the same as the parameter number from the process on an instrument. FlowDDE translates the node-address and process number to a channel number.

DDE-client applications communicate with the FlowDDE server by using DDE messages. Before messages can be exchanged, a DDE link has to be made. A DDE link consists of three parts: the server, the topic and an item. For separation the characters '|' and '!' may be used, so a DDE link in e.g. Microsoft Excel becomes: Server|Topic!Item.

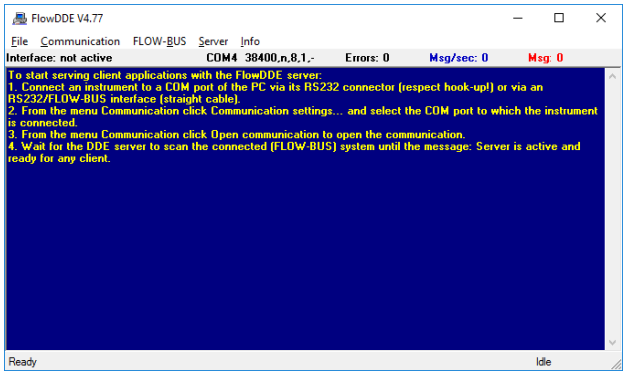
For standard instrument parameters and the FlowDDE server, these are:

- Server: FlowDDE or FlowDDE2
- Topic: 'C(X)' for channel number X
- Item: 'P(Y)' for parameter number Y

An example of a DDE link in a Microsoft Excel cell is =FlowDDE|'C(1)'!'P(8)' to read parameter 8 of channel 1.

When not using FlowDDE for communication with the instrument, parameters are addressed by:
- Node address of the instrument
- Process number on the instrument
- Parameter number on the instrument

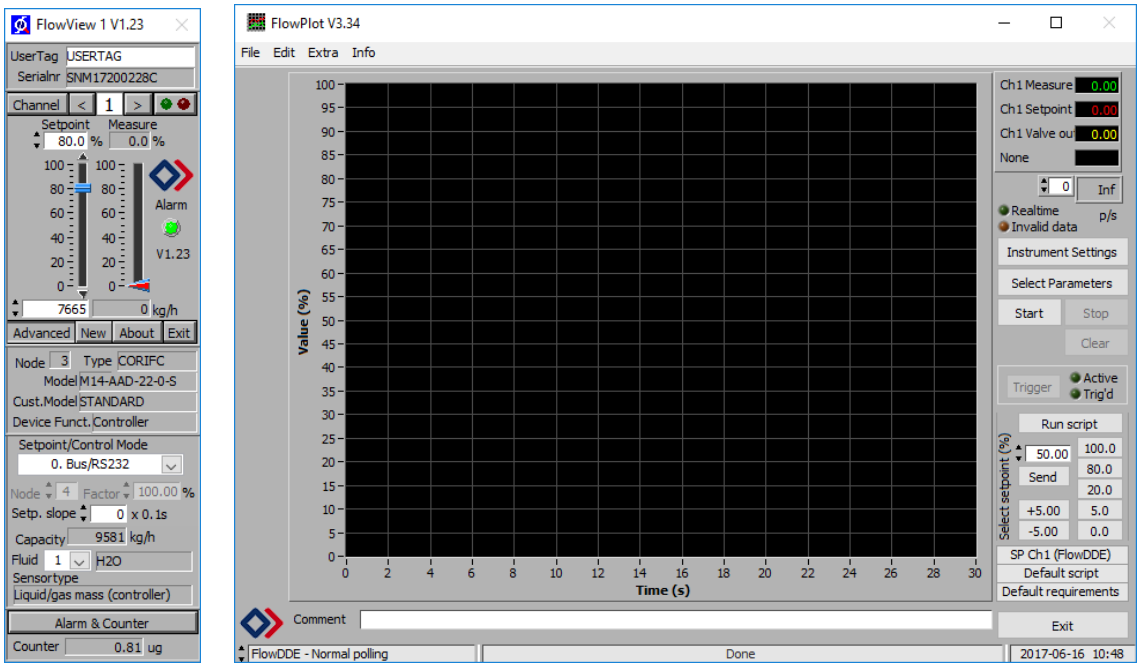
See section Digital parameters for more information about instrument parameters.



*For more information about FlowDDE, including setting up a DDE link, consult the **FlowDDE Manual** (document no. 9.17.067) or the help file in the application.*

3.7.2.2 Software (DDE applications)

Examples of free Bronkhorst® DDE client applications: FlowPlot and FlowView. Other software programs (third party) supporting DDE are for example MS-Office, LabVIEW, InTouch and Wizcon.



Bronkhorst® software applications 'FlowView' (left) and 'FlowPlot' (right)

FlowDDE and other Bronkhorst® applications are available on the support CD or can be downloaded from the product pages on the Bronkhorst website: ***www.bronkhorst.com/products***

3.7.3 Fieldbus operation

FLOW-BUS

Digital Bronkhorst® instruments can be monitored and operated via RS232 using the free **FlowWare** software tools for Windows. These tools provide a graphical interface to the ProPar protocol (used by FLOW-BUS), for monitoring and changing instrument parameters.

The FlowWare toolkit provides functionality for monitoring and operating digital instruments (FlowPlot, FlowView) and selection of the active fluid and configuration of the fieldbus connection (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***

Modbus

Instruments in a Modbus system can be monitored and operated using third party software as a master device, such as LabVIEW, ModScan, or a Modbus PLC.

PROFIBUS-DP
Instruments in a PROFIBUS DP system can be monitored and operated using third party software as a master device, such as TIA Portal (by Siemens).

To configure a device, a so-called GSD file (General Station Description) can be loaded into the software. The GSD file contains all necessary configuration information to operate the device in a PROFIBUS DP system, including communication and network configuration, and all available operating parameters with their data types.

A GSD file for Bronkhorst® instruments can be downloaded from the product pages on the Bronkhorst website:
www.bronkhorst.com/products

DeviceNet™
Instruments in a DeviceNet™ system can be monitored and operated using third party software as a master device, such as TIA Portal (by Siemens).

To configure a device, a so-called EDS file (Electronics Data Sheet) can be loaded into the software. The EDS file contains all necessary configuration information to operate the device in a DeviceNet™ system, including communication and network configuration, and all available operating parameters with their data types.

An EDS file for Bronkhorst® instruments can be downloaded from the product pages on the Bronkhorst website:
www.bronkhorst.com/products

3.8 Adjusting zero point

Zero-stability
Due to the mechanical characteristics of its sensor tube, a (very small) offset signal is inherent to a mass flow meter/controller. As a result of this zero-stability error, a flow may be detected when actually there is none.

The zero-stability error can be neutralized by adjusting the zero point of the instrument (the signal that corresponds to zero flow). Immediately after zeroing, the zero-stability error is 0%. In ideal situations, i.e. when process conditions are constant, the error will remain unchanged.

A certain tolerance around the zero point is allowable. Significant changes in ambient or process conditions, however, can affect the zero-stability error to the extent that the instrument needs to be adapted to the new conditions, by re-adjusting the zero point.

The zero point of a Bronkhorst® flow meter/controller is factory adjusted at approximately 20 °C and atmospheric pressure, with the instrument positioned upright. If the ambient conditions or mounting orientation are significantly different, zeroing a new instrument is recommended before using it for the first time.

The following factors affect the zero-stability error (in order of importance):

- fluid temperature
- ambient temperature
- mounting orientation
- (inlet) pressure
- fluid density
- fluid viscosity
- vibrations from the environment
- pressure fluctuations

The table below shows some typical worst case values for different mini CORI-FLOW models. In practice, zero stability will turn out to be better.

Model	DN (mm)	Zero stability error	Nominal flow
M12	0.25	< 0.02 g/h	100 g/h
M13	0.5	< 0.2 g/h	1 kg/h
M14	1.3	< 6 g/h	10 kg/h
M15	3.12	< 50 g/h	100 kg/h

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 with the operational media
- 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 absolutely essential; zeroing an instrument while there is still a flow will lead to measurement errors.

Methods
Adjusting the zero point of an instrument can be done by the following methods:

- manually (by using the multifunctional switch)
- digitally (via RS232 or fieldbus)
- with the autozero function of a Bronkhorst® readout and control unit (E-8000, BRIGHT)

Regardless of the preferred method, the procedure takes approximately 60 seconds to complete (longer if the output signal is unstable).

3.8.1 Manual procedure

To start the built-in 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 ● starts glowing for 4 seconds, after which the green LED ● starts glowing
3. At that moment (which is after 8 to 12 seconds), release the switch

The green LED starts to blink fast, indicating that the autozero function is being performed. On (successful) completion, the green LED starts to glow continuously, while the output signal is 0% (parameter *Measure* = 0).

3.8.2 Digital procedure

FlowPlot provides an easy way to adjust the zero point of an instrument via RS232; the Auto zero *function automatically performs the procedure described here*

To adjust the zero point using digital communication, set parameter values in the following sequence (see section Digital 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

The green LED starts to blink fast, indicating that the zeroing procedure is being performed. On completion, the green LED starts to glow continuously, while the output signal is 0% (parameter *Measure* = 0). At the same time, 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*

3.9 Checking calibration status

The calibration integrity of a mass flow meter for liquids can be verified in a relatively uncomplicated way by using an accurate weighing scale, or by comparing it with another mass flow meter with a known calibration status as a reference. This section describes a procedure for checking the calibration status with a weighing scale.

The counter functionality of the flow meter can be used to compare a batch with a configurable size (measured by the instrument itself) to the (real) weight of the displaced liquid that is measured by an accurate weighing scale. To operate the counter functionality, FlowPlot or a Bronkhorst® readout and control unit (E-8000, BRIGHT) can be used.

Apart from the instrument, the following items are needed for this calibration check:
- an accurate weighing scale
- a liquid container big enough to hold as much liquid as will get dosed in 2 minutes
- a readout and control facility, e.g.:
  - a Windows computer with FlowDDE and FlowPlot installed
  - a Bronkhorst® readout and control unit
- in case of a mass flow meter without control function: a shut off valve, to be installed downstream of the instrument

To perform a calibration check, follow these instructions:
1. Put the container on the weighing scale and tare it
2. Calculate the liquid mass that the instrument should measure in 2 minutes (based on a given setpoint or inlet pressure; see further)
3. Configure the counter of the instrument to stop the flow as soon as the calculated mass is reached
4. Reset the counter
5. Make sure that the inlet pressure is stable and sufficient for proper control and a stable flow rate
6. Open the valve to fill the container:
   a. controller: give a setpoint > 0%
   b. meter: open the shut off valve
7. When the configured batch size is reached, compare the measured liquid mass to the mass indicated by the weighing scale

When comparing both values, take the accuracy and the zero stability of the instrument into account: ± 0.2 RD (for liquids) + zero stability error (see Adjusting zero point).

The procedure described here is by no means a proper calibration procedure; it can only be used to get a quick impression of the calibration status of an instrument. Performing a reliable calibration procedure requires thorough knowledge of the many parameters involved. Bronkhorst has skilled and experienced staff available that can take care of calibration matters; contact your Bronkhorst representative for information.

3.10 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.

4 Digital parameters

Each instrument is controlled internally by a number of digital parameters, most of which can only be accessed using digital communication. Each communication protocol uses its own methods for communicating with instruments and accessing parameters.

This section describes the most commonly used parameters for digital operation of the mini CORI-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 RS232), parameters are identified by a unique combination of a process number and a parameter number:

[Pro]	Process number
[Par]	Parameter number

*Consult the **RS232 manual** (document no. 9.17.027) for detailed information.*

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.

Other interface protocols

Consult the specific fieldbus manual for accessing parameters using fieldbus communication (see Documentation).

A summary of all digital parameters described in this section can be found in the back of this manual.

4.1 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).

Temperature

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

This parameter returns the temperature in °C on the outside of the sensor tube, which is an approximation of the actual media temperature.

Pressure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	143	33/8	0xA140…0xA141/41281…41282

This parameter contains a fixed (reference) value that can be used for capacity calculations, etc. Its default value is equal to that of parameter *Inlet pressure*.

Density Actual

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	R	0…3.4E+38	270	116/15	0xF400…0xF401/62465…62466

This parameter returns the actual density measured by the instrument. If the selected *Capacity Unit* is a volume flow type, the instrument uses this parameter for conversion of the measured mass flow to the selected unit.

4.1.1 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

Controller output signal for driving the control valve, where 0…16777215 corresponds to 0…100%.

Sensor Type

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW 🔑	0…255	22	1/14	0x002E/47

The following sensor types are supported:

Instrument type	Value	Description
Controller	0	Pressure (counter disabled)
	1	Liquid volume
	2	Liquid /gas mass
	3	Gas volume
	4	Other (counter disabled)
Sensor	128	Pressure (counter disabled)
	129	Liquid volume
	130	Liquid/gas mass
	131	Gas volume
	132	Other (counter disabled)

4.2 Alarms

Alarm settings are most easily accessible using 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 used 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)

(For 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 bit-wise 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

Available reset methods for alarms. Up to 4 different methods can be specified; 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)

4.3 Counter

Counter settings are most easily accessible using 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 bit-wise 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	Micro-switch
1	2	Externally
2	4	By parameter *Reset*
3	8	Automatically (e.g. when counter value is reset)

4.4 Network configuration

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

Default settings
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 boldface):

Protocol	ProPar (RS232)	FLOW-BUS (RS485)	Modbus (RTU/ASCII)	PROFIBUS DP	DeviceNet™
Address	**3**	**3**…125	**1**…247	0…**126**	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	**125000** 250000 500000
Parity	**0**	**0**	0, 1, **2**	**2**	**0**

Communication via fieldbus connection (top connector, RS485)
Using the RS232 interface, set the following parameters to configure the instrument for communication via the fieldbus connection:

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 connection (RS232/RS485)
Use the following parameters to configure the instrument for FLOW-BUS or Modbus communication via the side connector:

- *If the 8-pin DIN connector is set for RS485 communication, the instrument will not respond when connected to an RS232 configuration. In that case, use the power-up functionality of the multifunctional switch to enter configuration mode and enable RS232 communication.*
- *After configuring the required parameters, use the same procedure to leave configuration mode and restore the original communication settings (otherwise, configuration mode remains enabled after power down).*

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

4.5 Fluid set

Fluid Set Index

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char	RW	0…7	24	1/16	0x0030/49

With this parameter, any of the pre-configured fluids (up to 8) can be selected. Each fluid has its specific (configurable) properties, such as *Fluid Name*, *Capacity*, etc.
Default value: 0 (fluid 1).

Fluid Name

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[10]	RW	-	25	1/17	0x8188…0x818C/33161…33165

This parameter contains the name of the current fluid.

Capacity

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	1E-10… 1E+10	21	1/13	0x8168…0x8169/33129…33130

This parameter sets the maximum readout/control value (100%) for the current fluid in readout units corresponding to *Capacity Unit*.

Capacity Unit

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Unsigned char[7]	RW	see below	129	1/31	0x81F8…0x81FB/33273…33276

Available units:

Mass flow	Normal volume flow (1.01325 bar(a), 0 °C)	Standard volume flow (1.01325 bar(a), 20 °C)	Custom volume flow (*Capacity Unit Type Pressure*, *Capacity Unit Type Temperature*)
ug/h, ug/min, ug/s, mg/h, mg/min, mg/s, g/h, g/min, g/s, kg/h, kg/min, kg/s	uln/h, uln/min, uln/s, mln/h, mln/min, mln/s, ln/h, ln/min, ln/s, ccn/h, ccn/min, ccn/s, mm3n/h, mm3n/m, mm3n/s, cm3n/h, cm3n/m, cm3n/s, m3n/h, m3n/min, m3n/s, scfh, scfm, scfs, sccm, slm	uls/h, uls/min, uls/s, mls/h, mls/min, mls/s, ls/h, ls/min, ls/s, ccs/h, ccs/min, ccs/s, mm3s/h, mm3s/m, mm3s/s, cm3s/h, cm3s/m, cm3s/s, m3s/h, m3s/min, m3s/s	ul/h, ul/min, ul/s, ml/h, ml/min, ml/s, l/h, l/min, l/s, cc/h, cc/min, cc/s, mm3/h, mm3/m, mm3/s, cm3/h, cm3/m, cm3/s, m3/h, m3/min, m3/s, cfh, cfm, cfs

Because of the maximum string length (7 characters), some unit names are abbreviated. For instance mm3n/m means mm^3n/min.

Capacity Unit Type Temperature

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	-273.15… 3.4E+38	245	33/10	0xA150…0xA151/41297…41298

This parameter defines a reference temperature for conversion of the measured mass flow to a volume flow. See also parameters *Capacity Unit* and *Counter Unit*.

Capacity Unit Type Pressure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	246	33/11	0xA158…0xA159/41305…41306

This parameter defines a reference pressure for conversion of the measured mass flow to a volume flow. See also parameters *Capacity Unit* and *Counter Unit*.

4.5.1 Advanced fluid set parameters

Note that the parameters described in this section do not contain any actual measurement values, but only fixed reference values, which can be used for capacity calculations, etc.

Inlet Pressure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	178	113/13	0xF168…0xF169/61801…61802

Inlet pressure of the current fluid in bar(a)

Outlet Pressure

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	179	113/14	0xF170…0xF171/61809…61810

Outlet pressure of the current fluid in bar(a).

Fluid Temperature

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	-250…500	181	113/16	0xF180…0xF181/61825…61826

Temperature of the current fluid in °C.

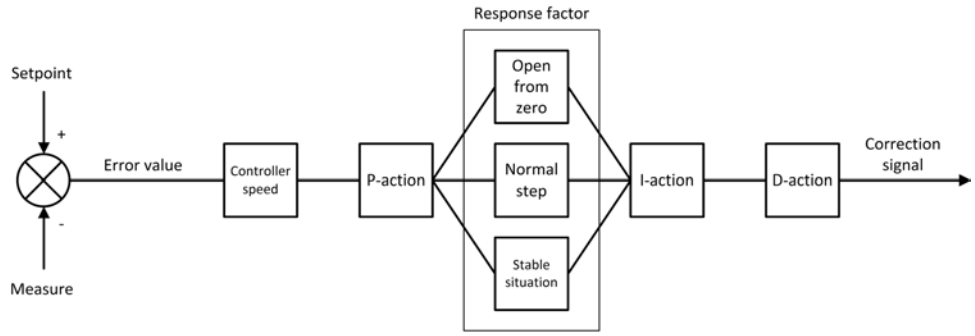
Density

Type	Access	Range	FlowDDE	FLOW-BUS	Modbus
Float	RW	0…3.4E+38	170	33/21	0xA1A8…0xA1A9/41385…41386

Density of the current fluid in kg/m^3

4.6 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.

*For more information about controlling characteristics, consult the **FlowPlot manual** (document no. 9.17.030).*

Because controlling characteristics are optimized during manufacture, Bronkhorst strongly advises not to change these parameters. If changing controller settings is absolutely necessary, it should be performed by or under supervision of trained service personnel only.

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 set. *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* * $1.05^{(\text{response factor - 128})}$

4.7 Master/slave configuration (FLOW-BUS)

Normally, there is no communication between slave 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 connected to a FLOW-BUS network is automatically available to all other instruments without extra wiring. A slave instrument can in turn 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.

Setpoints from master instruments can be received via FLOW-BUS only.

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 only is effective in a FLOW-BUS system via RS485.

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 RS485, *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%

4.8 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.

4.9 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 int	RW	0…255	12	1/4	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/RS232
1	Analog Input	Controlling	Analog input
2	FLOW-BUS Slave	Acting as slave instrument on FLOW-BUS	RS485 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*/00%
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	RS485 only: FLOW-BUS master output x *Analog Input*
18	RS232	Controlling, safe state deactivated	Fieldbus/RS232
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.

4.9.1 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.*

5 Troubleshooting and service

To track down problems in the fluid system, it is recommended to disconnect the unit from the process line and check it without fluid pressure. Dirt or clogging might be detected quickly by loosening fluid connections and performing a visual inspection.

Energizing and de-energizing the equipment can indicate whether there is an electronic failure. After energizing, control behavior can be checked by applying fluid pressure.

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

5.1 Errors and warnings

See LED indications for an explanation of all possible LED indications.

In case of problems during operation, error and warning information can be found in FlowDDE and FlowPlot. FlowDDE puts all errors and warnings on the console screen; FlowPlot provides several alarm and counter indicators. See also section Digital RS232 operation.

5.2 Restoring factory settings

In case changes to the instrument configuration leads to non-recoverable erroneous behavior, the instrument can be reset to the pre-configured factory settings. This can be done with the following methods:

- with the multifunctional switch (see Multifunctional switch)
- with the *restore* function of a Bronkhorst® readout and control unit (BRIGHT, E-8000)
- via RS232 communication, with the *Restore settings* function in FlowPlot

*Changes made to the network settings (bus address, baud rate, parity) will **not** be restored by a factory reset.*

5.3 Common issues

Symptom	Possible cause	Action
Red LED glows continuously	No liquid in measuring tube	Flush instrument with process fluid prior to starting measurement and control (see First use)
	Slug flow (combined gas and liquid flow)	Make sure the measuring tube only contains either gas or liquid (see First use)
	Hardware error	Return equipment to factory
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)
	Other	Reset instrument and/or restart master. Contact Bronkhorst if problem persists.
No output signal	No power supply	• Check power supply • Check cable connection • Check cable hook-up
	Inlet pressure or differential pressure too low	Increase inlet pressure
	Piping, filters and/or control valve clogged or blocked	• Clean system (flush with clean, dry air or a non-aggressive cleaning liquid (e.g. ethanol or isopropyl alcohol)

Symptom	Possible cause	Action
		• For external proportional control valves: supply 0…15 Vdc and operational inlet pressure to valve and slowly increase voltage. If valve does not open, clean parts and re-adjust valve
	Sensor failure	Return equipment to factory
• Control behavior unstable • Red LED flashes irregularly	Gas accumulation in tubing	Flush the system to remove gas Tip: use frequency or density signal to detect presence of gas bubbles
	Measurement disturbed by mechanical vibration	• If possible, avoid installation in close proximity of mechanical vibration • Reduce sensitivity to vibrations by using a mass block, dampeners, and flexible tubing
	Inlet pressure unstable	Eliminate pressure fluctuations, e.g. by installing a pressure regulator
	Wrong controller settings	Adjust settings (e.g. with FlowPlot)
No flow (sending a setpoint has no effect)	No fluid supply	Check upstream components for obstruction, e.g.: • fluid lines • valves • filters
	Inlet pressure or differential pressure out of bounds	Set inlet pressure to a value within specifications
Flow rate rises, but never reaches setpoint	Piping, filters and/or control valve clogged or blocked	• Clean system (flush with clean, dry air or a non-aggressive cleaning liquid (e.g. ethanol or isopropyl alcohol) • For external proportional control valves: supply 0…15 Vdc and operational inlet pressure to valve and slowly increase voltage. If valve does not open, clean parts and re-adjust valve
	Inlet pressure too low	Increase inlet pressure
	Outlet pressure too high	Check outlet pressure
	Process outlet blocked	Check process outlet and downstream piping
Measured value or output signal much lower than setpoint	Inlet pressure or differential pressure too low	• Increase inlet pressure • Use instrument in conditions it was designed for
	Piping or filters blocked or contaminated	Clean system
	Sensor blocked or contaminated	Clean sensor
	Valve blocked or contaminated	Clean valve
	Supplied fluid type does not match configured fluid type	Supply equipment with other fluid or change fluid type in instrument configuration
Measured value or output signal indicates a flow, while there should be none	Mounting orientation and/or ambient conditions changed significantly	• Use instrument in conditions it was designed for • Adjust zero point (see Adjusting zero point)
	Control valve leaking	Clean valve; if problem persists, return equipment to factory
	System leakage	Check the system for leakage. Follow vendor instructions when installing third party components (e.g. adapters, tubing, valves)

Symptom	Possible cause	Action
Continuous maximum measured value or output signal	Inlet pressure too high	Check inlet pressure
	Control valve (normally open) failure	Return equipment to factory
	Sensor failure	Return equipment to factory
Flow rate decreases gradually	Condensation on measuring tube (might occur with NH_3 and some hydrocarbons, such as C_3H_8, C_4H_{10})	Increase media temperature to above ambient conditions
Measured flow rate erroneous	Calibration status compromised	Check calibration status

5.4 Service

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:

support@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

6 Returns

6.1 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.)

6.2 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). As a consequence, Bronkhorst offers its customers the opportunity 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, you can 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).

For customers outside the EU, local or national directives and/or legislation may apply to EEE disposal. If applicable, consult local or national authorities to learn how to handle EEE properly in your area.

Parameter index

Parameters