FLUIFILL® Dosing Control

Batch dosing control for
MI1x0, ML1x0, ES-1xx

Manual

English

IMPORTANT!
Read carefully before use.
Keep for future reference.

Bronkhorst®

Table of Contents

1 General information

1.1 Symbols and signal words in this document

The following symbols and signal words are used to indicate the type of information or to indicate a possible risk.

NOTICE

Signal word used to indicate a potential risk of damage to the product.

Important information and recommendations

Important information where there is no risk to people or product.

1.2 General safety instructions

⚠ Please read this document and all other applicable documents carefully before using FLUIFILL® dosing control.

- All instructions must be observed. Failure to comply with instructions may result in material damage and personal injury, including danger to life.
- These instructions are applicable to the Bronkhorst® products stated on the front cover of this manual only.
- If in any doubt, please contact Bronkhorst. For contact information, see the back cover of this manual.

⚠ Intended use

The FLUIFILL® has been developed to control the dosing of liquids in a dosing application. The dosing control functionality is part of the firmware of a Bronkhorst® product. As such, it is an extension of the firmware described in the comprehensive product manual available online.

► Refer to the online manuals for a complete understanding of the product's functionality in relation to FLUIFILL®.

⚠ Notices for the target group

The user and/or installer are/is considered to have professional experience level and knowledge about installation, operational requirements for its industry and type of application and national requirements according to relevant standards and regulations.

2 Product information

2.1 Introduction

FLUIFILL® dosing control simplifies the process of achieving fast and reliable dosing results. It utilizes an automatic set-up function to ensure the 'First-Time-Right' principle. FLUIFILL® dosing control focuses on batch dosing applications.

2.2 About this document

Illustrations used

The illustrations in this document serve to provide general notices regarding correct operation. The illustrations are simplified representations of the actual situation.

Document validity
Documents are updated regularly. The most recent version is available online.
► Prior to work, check whether a newer version of this document is available on the Bronkhorst website.
► For download information, see the back cover of this manual.

2.3 Product scope

The table below shows the products for which the firmware with dosing control functionality applies. The Bronkhorst® products can be recognized by the first part of the model key:

Product series	Model key
mini CORI-FLOW™	ML120V00, ML120V21
mini CORI-FLOW™	MI130, MI140
ES-FLOW	ES-103I, ES-113I
ES-FLOW	ES-102C, ES-112C, ES-113C

Tab. 1. Product scope

2.4 Bronkhorst FlowSuite™

Bronkhorst FlowSuite is intended to be used to easily configure and control Bronkhorst® products. It is not intended to control critical processes, but can be used to control and monitor research and pilot setups.

Bronkhorst FlowSuite recognizes instruments with the FLUIFILL® dosing control on board, and allows dosing settings to be adjusted and monitored via the interface.

To install Bronkhorst FlowSuite:
► Go to the Bronkhorst website.
► Browse to the software web-page to download the software application.
► Follow the on-screen instructions to install the application on a Windows PC.

2.5 Abbreviations used

Abbreviation	Meaning
R/W	Read/Write
Uint8	8 bit unsigned char
Uint16	16 bit unsigned integer
Uint32	32 bit unsigned long integer
PID	Proportional Integral Derivative

Tab. 2. Abbreviations

3 System preconditions

For optimal accuracy it is important that the following conditions are taken into account:

Inlet pressure
The inlet pressure will determine the flow velocity.
- Too high pressure will lead to overshoot and unstable results.
- Too low pressure will result in non-achieved batch limits.

► Provide a stable and the correct inlet pressure.
► See the serial number label on the product for the correct inlet pressure.

Liquid flow

The system or liquid should be free of gas bubbles. The presence of gas bubbles lead to slow system response times and flow measurement when the valves are closed. The negative effect of gas bubbles increases with lower/shorter dosages (mg, ms).

► Make sure the liquid in the application is gas bubble free.

Turbulence

The amount of piping, reducers, connections and t-parts should be restricted to avoid a turbulent flow.

► Use tubing/piping size which is appropriate to the flow rate.
► Adjust Zero point at actual process conditions.

4 Dosing basics

4.1 Dosing types

FLUIFILL® dosing control supports 2 types of batch dosing, each with its own use case:

- ON/OFF controlled dosing- Apply if dosing is controlled with an on-off valve.
- PID controlled dosing - Apply if dosing is controlled with a control valve or a pump.

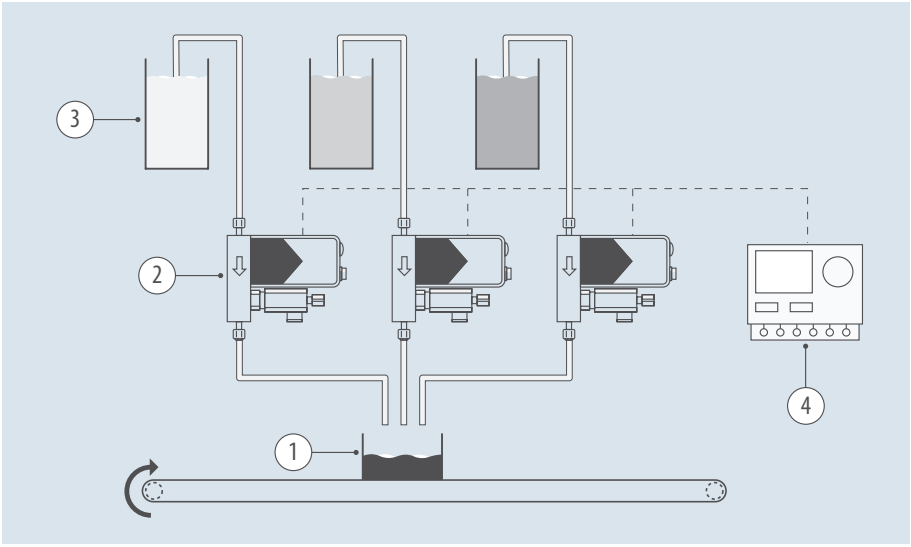

Fig. 1. Example - PID controlled dosing

1. Collecting barrel
2. Flow controller
3. Storage vessel
4. Control unit (e.g. PLC)

PID controlled dosing

For this type of dosing, a pump / control valve is used. Dosing control consists of controlling the time the pump / control valve is actuated, in combination with the setpoint of the PID control function of the product.

ON/OFF controlled dosing
For this type of dosing, an ON/OFF valve is used. Dosing control consists of controlling the time during which the valve is actuated, in combination with the applied supply pressure.

4.2 Dosing type selection

► Check the dosing method using the following parameters:

Par. name	Type	R/W	DDE	Proc./Par	Value
Dosing type	Uint8	R[1]	398	112 / 1	2 - Batch
Dosing controller type	Uint8	R[1]	399	112 / 2	0 - PID 1 - ON/OFF

Tab. 3. Dosing type selection

4.3 PID controlled dosing

Automatic setup procedure

The automatic set-up procedure only needs to be performed once. Only in case of changes to the system or fluid, the set-up procedure must be repeated.

The automatic setup procedure must be completed to dose First Time Right. The following steps are included in the setup procedure and performed automatically:

Step	Function	Description	Approx. duration [s]
1	Auto Zero	Automatic zero flow offset	20
2	Counter threshold determination	Noise level of the measured value	30
3	Learn valve open	Determination of the valve output signal at which flow starts	4
4	Auto-Kp	Automatic determination of the Kp value	70
5	Data collection First Time Right dosing	Calculation corrections before dosing with new dosing size and/or batch delivery time starts	35 ... 40
		Total time	**± 3 min.**

Tab. 4. PID controlled dosing - Automatic setup procedure

► Run the setup procedure by setting the Control mode and the Calibration mode.

Par. name	Type	R/W	DDE	Proc./Par	Value
Control mode[2]	Uint8	RW	12	115 / 1	9
Calibration mode	Uint8	RW	58	1 / 4	23

Tab. 5. PID controlled dosing - Parameters

1) Factory configuration, as ordered
2) InitReset = 64, to unlock secured parameters

4.4 ON/OFF controlled dosing

Automatic setup procedure

The automatic set-up procedure only needs to be performed once. Only in case of changes to the system or fluid, the set-up procedure must be repeated.

The automatic setup procedure must be completed to dose First Time Right. The following steps are included in the setup procedure and performed automatically:

Step	Function	Description	Approx. duration [s]
1	Auto Zero	Automatic zero flow offset	20
2	Counter threshold determination	Noise level of the measured value	30
3	Data collection First Time Right dosing	Calculation corrections before dosing with new dosing size and/or batch delivery time starts	35 ... 40
		Total time	**± 1.5 min.**

Tab. 6. ON/OFF controlled dosing - Automatic setup procedure

► Run the setup procedure by setting the Control mode and the Calibration mode.

Par. name	Type	R/W	DDE	Proc./Par	Value
Control mode	Uint8	RW	12	115 / 1	9
Calibration mode	Uint8	RW	58	1 / 4	23

Tab. 7. ON/OFF controlled dosing - Parameters

4.5 Automatic setup fluid usage

During automatic setup, and depending on the selected dosing type, an amount of fluid is used.

PID controlled dosing

The amount of fluid that is being used during the automatic setup procedure is 85% of the mass or volume per minute. Examples:

Capacity = 300 ml/min
Fluid usage: 300 x 85% = 255 ml

Capacity = 18 kg/h = 18 kg/ 60 min = 0.3 kg/min
Fluid usage: 0.3 x 85% = 0.255 kg

ON/OFF controlled dosing

The amount of fluid that is being used during the automatic setup procedure is 2.1 times the mass or volume per second. Examples:

Capacity = 600 ml/min = 600 ml/ 60 sec = 10 ml/s
Fluid usage: 10 x 2.1 = 21.0 ml

Capacity = 36 kg/h = 36 kg/ 3600 sec = 0.01 kg/s
Fluid usage: 0.01 x 2.1 = 0.021 kg

4.6 Automatically stop dosing

Dosing can be stopped automatically after reaching a certain amount of liquid, e.g. when the liquid supply is empty. To stop dosing automatically:

- ► Set Counter mode to Up-to-limit
- ► Set Counter limit to the desired amount.

When the Counter limit is reached (Counter value >= Counter limit), dosing is stopped automatically (Dosing mode = 0).

- ► To start dosing again, reset Counter Value.

Par. name	Type	R/W	DDE	Proc./Par	Value
Counter mode	Uint8	RW	130	104 / 8	2
Counter limit[3]	Float	RW	124	104 / 3	0 ... 9999999
Counter value	Float	RW	122	104 / 1	0 ... 10000000

Tab. 8. Automatically stop dosing

5 Dosing modes

There are 4 different dosing modes available : Dosing mode = 0, Dosing mode = 1. Dosing mode = 2, Dosing mode = 3

5.1 Dosing disabled (dosing mode= 0)

In this mode dosing is disabled.

5.2 Software trigger (dosing mode= 1)

Using the software trigger for dosing, only a single batch is dosed. When the batch amount is reached, dosing is disabled (Dosing Mode = 0).

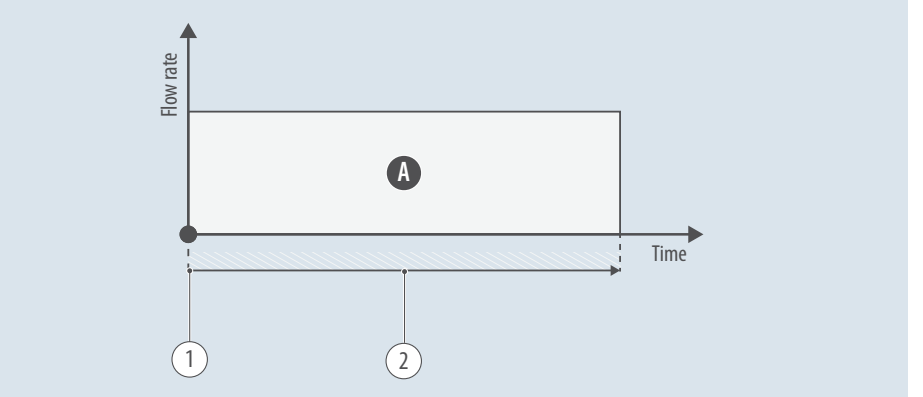

Fig. 2. Dosing mode - Software trigger

A. One batch
1. Software trigger
2. Batch delivery time

3) Storage vessel capacity

5.2.1 Dosing mode ignore

In fieldbus systems with cyclic communication, there is a risk that a new batch will be started immediately after a batch has been completed. To stop this “cyclic” behavior, an additional “dosing mode=255” must be added immediately after the selected dosing mode=1 to stop dosing after a batch has finished. A new batch can be started by entering dosing mode = 1, followed by dosing mode = 255.

5.3 External hardware trigger (dosing mode=2)

Using an external hardware trigger for dosing, only a single batch is dosed after each trigger. Optional, a start delay can be added to align the hardware trigger with the exact dosing moment.

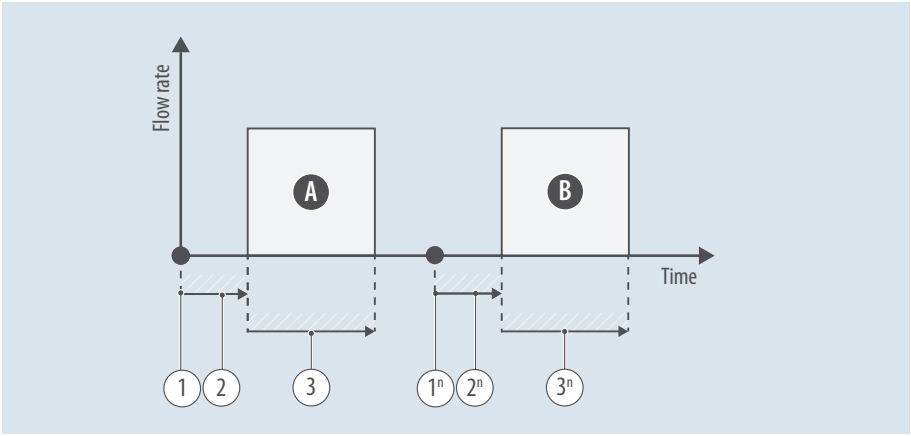

Fig. 3. Dosing mode - External hardware trigger

A. First batch
B. Next batch
1. Hardware trigger
2. Batch start delay time
3. Batch delivery time

5.4 Repetitive dosing (dosing mode=3)

Using Repetitive dosing, multiple batches are dosed. The time between the start of 2 consecutive batches is set by the Batch repetition time. Dosing continues until dosing mode is disabled (dosing mode=0).

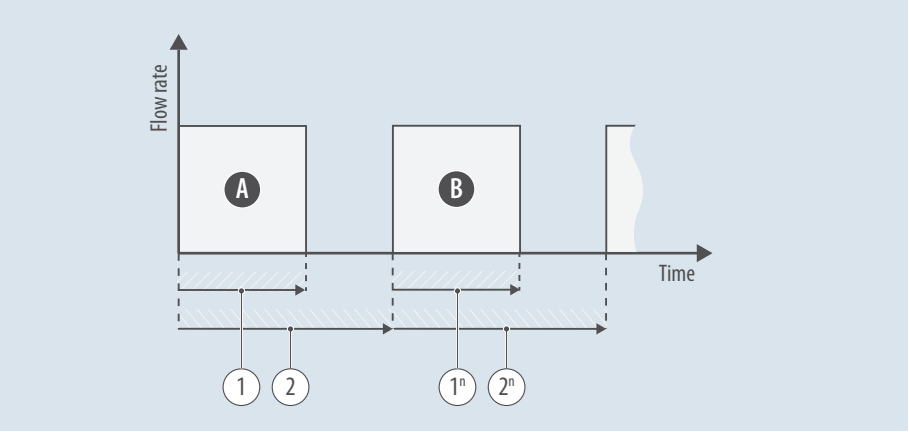

Fig. 4. Dosing mode - External hardware trigger

A. First batch
B. Next batch
1. Batch delivery time
2. Batch repetition time

5.5 Dosing start

Write actions

After the automatic setup procedure has been executed successfully the following parameters must be set to start dosing:

Par. name	Type	Unit	DDE	Proc./Par	Value
Batch rejection mode	Uint8	R/W	400	112 / 3	0: disabled 1: hardware trigger is given when batch deviation exceeds batch deviation alarm
Batch start delay time	Float	R	402	112 / 5	Time between an external hardware trigger and the actual start of dosing (when Dosing mode = 2)
Batch delivery time	Float	R	403	112 / 6	Duration of a single dose (> 0)
Batch repetition time	Float	R	404	112 / 7	Time between the start of a dose and the start of the next dose (when Dosing mode = 3)
Batch amount	Float	R	405	112 / 8	Amount of liquid to be used in 1 batch (> 0).

Par. name	Type	Unit	DDE	Proc./Par	Value
Batch deviation alarm	Float	R/W	406	112 / 9	Setting for the maximum deviation (in percentage of Batch Amount) before the alarm is activated. 0: disabled > 0, batch deviation alarm active
Batch dosing unit			410		Unit of the (actual) Batch Amount (uses counter unit table and is selectable within counter unit type) (» par. 5.5.1, page 13))
Dosing mode	Uint8	R/W	401	112 / 4	0: disabled 1: software trigger 2: external hardware trigger 3: repetitive dosing 255: dosing mode ignore (» par. 5.2.1, page 11))

Tab. 9. Write actions dosing

Read actions

The actual dosing result can be read through the following parameters:

Par. name	Type	R/W	DDE	Proc./Par	Value
Actual batch amount	Float	R	407	112 / 10	
Actual batch delivery time	Float	R	408	112 / 11	
Batch deviation	Float	R	409	112 / 12	The batch deviation is calculated as follows: Actual batch amount – Batch amount) / Batch amount) * 100 %

Tab. 10. Read actions dosing

5.5.1 Batch dosing unit

NOTICE

All available counters use the same unit type (mass or volume). Changing the unit type of one of the counters from 'volume' to 'mass' (or vice versa) will (re)set the value of all counters to '0'.

When changing the Batch dosing unit to a unit from an other unit type (e.g. from 'ml' (Volume) to 'g' (Mass)), the unit of the following counters will be set to a unit from that unit type:

- Counter unit
- Totalizer unit

► Refer to the online available comprehensive manual of the instrument for an overview of the possible units.

► For download information, see the back cover of this manual.

6 Diagnostics

Diagnostic data will be stored for certain events. In the diagnostic buffer up to 50 events can be stored. When the buffer is full, oldest events will be overwritten by newest events.

When using Bronkhorst FlowSuite™ the icon colors are based on the NAMUR NE 107 standard and are a simplified representation of the diagnostic data.

Icon	NAMUR status	Signal status
	Normal operation	Valid output signal
	Maintenance required	Output signal still valid.
	Out of specification	Signal out of the specified range
	Check function	Output signal temporary non-valid.
	Critical failure	Non-valid output signal

Tab. 11. Product status definitions

6.1 Reading diagnostic data

Diagnostic data can be retrieved from the instrument as follows:

- ► Read the Diagnostic newest event index.
- ► Write the value to the Diagnostic event index.
- ► Read the Diagnostic event code, the Diagnostic event description (414) and the Diagnostic event active.

For older events

- ► Lower the value of the Diagnostic event index.
- ► Read the Diagnostic event code, the Diagnostic event description (414) and the Diagnostic event active.

Par. name	Type	R/W	DDE	Proc./Par	Value
Diagnostic newest event index	Uint16	R	411	118/14	0 ... 49
Diagnostic event index	Uint16	R/W	412	118/15	0 ... 49
Diagnostic event code	Uint16	R	413	118/16	
Diagnostic event description	String	R	414	118/20	
Diagnostic event active	Uint8	R	415	118/17	0 - Not active 1 - Active
Diagnostic event NAMUR status	Uint8	R	416	118/18	1 - Maintenance required 2 - Out of specification 4 - Check function 8 - Failure
Diagnostic event timestamp	Uint32	R	417	118/21	≥ 0 - value of operation time [s] when the event occurs

Par. name	Type	R/W	DDE	Proc./Par	Value
Instrument NAMUR status	Uint8	R	418	118/0	0 - Normal 1 - Maintenance required 2 - Out of specification 4 - Check function 8 - Failure

Tab. 12. Diagnostic parameters

6.2 Diagnostic codes

The following table lists the diagnostic codes. Additional information for codes that appear in bold is available in 6.2.1 on page 15.

Code	NAMUR	Description
5500		Auto setup procedure (incl. auto-zero, counter threshold, etc.)
5501		Auto setup procedure failed
5502		First Time Right data collection
5503		First Time Right data collection failed
5504		Batch deviation exceeded Batch deviation limit
5505		Batch delivery time exceeded
5506		Capacity differs from capacity during dosing setup
5507		Parameter unavailable
5508		Flow does not reach setpoint (check controller- and/or filter settings)
5509		Time valve open too short (correct dosing behavior not guaranteed)
5510		Dosing not possible (no flow?)
5511		First Time Right dosing not guaranteed (run auto-setup)
5512		Batch dosing unit type changed (mass flow / volume flow)
5513		Dosing stopped, counter limit reached

Tab. 13. Diagnostic codes

6.2.1 Additional diagnostic codes

Additional info to code 5500

Code	Description
22003	Auto setup, auto zeroing sensor
22005	Auto setup, auto determination counter threshold
22007	Auto setup, determination of actuation level where flow > 0
22009	Auto setup, auto Kp controller

Code	Description
22010	Auto setup, First Time Right data collection

Tab. 14. Additional info to code 5500

Additional info to code 5501

Code	Description
22000	Auto setup, cannot start (check dosing parameters)
22001	Auto setup, invalid setpoint
22002	Auto setup, timeout occurred
22004	Auto setup, auto zeroing sensor failed
22006	Auto setup, auto determination counter threshold failed
22008	Auto setup, determination of actuation level where flow > 0 failed
22011	Auto setup, First Time Right data collection failed

Tab. 15. Additional info to code 5501

Additional info to code 5503

Code	Description
22012	First Time Right data collection, cannot start (check dosing parameters)
22013	First Time Right data collection, invalid setpoint
22014	First Time Right data collection, timeout occurred

Tab. 16. Additional info to code 5503

7 Dosing specifications

Batch delivery time specification

Dosing controller type	Unit	Value
PID controlled dosing	ms	≥ 4000
ON/OFF controlled dosing	ms	≥ 20

Tab. 17. Batch delivery time specification

Batch repetition time specification

Dosing mode	Unit	Value
Disabled	ms	--
External software trigger	ms	> 70
External hardware trigger	ms	> 70
Dosing repetition interval	ms	> 70 AND > batch delivery time

Tab. 18. Batch repetition time specification

7.1 Full parameter list

Par. name	Type	R/W	DDE	Proc./Par	Value
Counter value	Float	R/W	122	104/1	0 ... 10000000
Counter limit	Float	R/W	124	104/3	0 ... 9999999
Counter mode	Uint8	R/W	130	104/8	0 ... 2
Dosing type	Uint8	R[4]	398	112 / 1	2 - Batch
Dosing controller type	Uint8	R	399	112 / 2	0 - PID 1 - ON/OFF
Batch rejection mode	Uint8	R/W	400	112 / 3	0 - Disabled 1 - Batch deviation (batch deviation > batch deviation alarm)
Dosing mode	Uint8	R/W	401	112 / 4	0 - Disabled 1 - Software trigger 2 - Hardware trigger 3 - Repetition interval
Batch start delay time	Float	R	402	112 / 5	≥ 0.0 s (resolution = 1 ms)
Batch delivery time	Float	R	403	112 / 6	> 0.0 s (resolution = 1 ms)
Batch repetition time	Float	R	404	112 / 7	Time between the start of a dose and the start of the next dose (when Dosing mode = 3)
Batch amount	Float	R	405	112 / 8	≥ 0.0
Batch deviation alarm	Float	R/W	406	112 / 9	%
Actual batch amount	Float	R	407	112 / 10	
Actual batch delivery time	Float	R	408	112 / 11	
Batch deviation	Float	R	409	112 / 12	((actual Batch Amount – Batch Amount) / Batch Amount) * 100%
Batch dosing unit	string	R	410	112 / 0	Unit of the (actual) Batch Amount (uses counter unit table and is selectable within counter unit type)
Batch dosing status	uint16	R	434	112 / 13	Bit 0: dosing ready Bit 1: dosing error Bit 2: actual dosing deviation > dosing deviation limit
Dosing sequence number	uint32	R/W	437	112 / 14	Writing 0 will reset the value to 0 Writing values > 0 will be ignored

Tab. 19. Full parameter list

4) Factory configuration, as ordered

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Service & Support

Contact

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