

mini CORI-FLOW™

Compact Coriolis Mass Flow Meters & Controllers for
Liquids and Gases



Gas & Liquid

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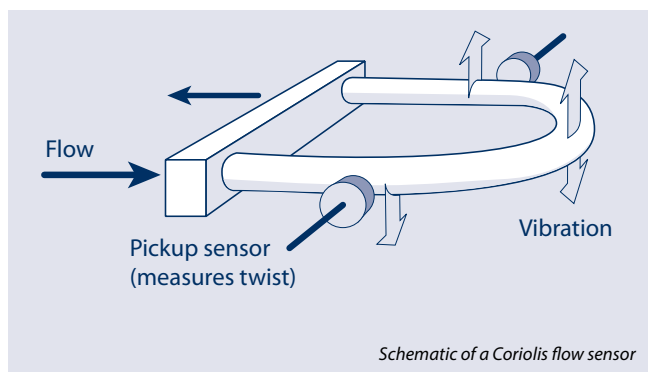
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Facts about Coriolis Flow Measurement and Control

Coriolis principle of operation

In 1835 Gaspard-Gustave Coriolis, a French scientist, described the effect that moving objects deflect from a straight path when they are viewed from a rotating frame of reference. In the nineteen seventies the "Coriolis effect" started to find applications in mass flow meters: a fluid flows through a vibrating tube and causes changes in frequency, phase shift or amplitude, proportional to the mass flow through the tube, giving the density of the fluid as secondary output.



Coriolis versus other principles of flow measurement

Other flow meter principles measure the velocity, volume or differential pressure and it is necessary to correct for density and/or for pressure and temperature in order to determine the mass flow of a particular fluid stream. The direct measurement of the mass flow is generally much more accurate. Thermal Mass Flow Meters show a direct, proportional relation between mass flow and a temperature difference, picked up by a sensor. However, since these instruments operate on the basis of heat transfer, their calibrations are dependent of the fluid's specific heat. Not so for Coriolis Mass Flow meters! The flow meters exactly measure the throughput of fluid, no matter if it is gaseous or in the liquid phase. Furthermore Coriolis Mass Flow Meters distinguish themselves by their high accuracy and fast response time.

Current market of Coriolis mass flow meters

Traditionally, Coriolis Mass Flow Meters are mainly applied for medium to high flow rates of liquids. Applications are found in industrial processes e.g. in chemical plants, the oil & gas market and in the food and beverage industry. Measuring low flow rates has, so far, been complicated and costly.

The mini CORI-FLOW™ solution

Coriolis principle of operation

The objective for the development of the **mini CORI-FLOW™** series was to achieve a compact, cost-effective Mass Flow Meter/Controller for accurate measurement and control of (very) low flow rates. The unique design of the miniature Coriolis sensor features unsurpassed performance, even with changing operating conditions in pressure, temperature, density, conductivity and viscosity.

Compact Coriolis Mass Flow Controllers

Contrary to many other Coriolis flow meters on the market, **mini CORI-FLOW™** offers integrated PID control and close-coupled control valves or pumps, thus constituting very compact, cost- and space-saving Coriolis Mass Flow Controllers.

Not just liquids but also gases

Unlike some other Coriolis Mass Flow meters, **mini CORI-FLOW™** can also be applied for gas flow applications.

(Very) low flow ranges

The unique sensor design of **mini CORI-FLOW™** permits accurate measurement of flow rates as small as 0,1...5 g/h (1,3...66,6 ml_n/min N₂) up to 0,3...30 kg/h (4...400 l_n/min N₂).

Digital technology for RS232 and fieldbus communication

mini CORI-FLOW™ features state-of-the-art digital technology, offering fieldbus interface options and additional functions such as totalisation and alarms.

The instruments can be tuned according to customer requirements using the RS232/fieldbus interface and a number of free to use software tools.

Alternative to thermal MFCs

mini CORI-FLOW™ was designed to enable easy exchange of traditional thermal MFCs. **mini CORI-FLOW™** flow controllers have the same footprint and also electrically the instruments feature the same options for analog and fieldbus communication. Compared to thermal MFCs, Coriolis based flow controllers are more accurate, faster and offer independence from fluid properties.

mini CORI-FLOW™ Mass Flow Meters

General

mini CORI-FLOW™ series by Bronkhorst® are precise and compact Mass Flow Meters and Controllers, based on the Coriolis measuring principle. Designed to cover the needs of the low flow market, there are 3 models to overlap flow ranges from 5 g/h up to 30 kg/h (full scale values), each offering “multi-range” functionality: factory calibrated ranges can be rescaled by the user, maintaining the original accuracy specs. As a result of this, customers are able to reduce the variety of instruments and thus reduce the cost of ownership. The instruments are equipped with a robust IP65 weatherproof housing and are available with optional ATEX approval for use in Zone 2 hazardous areas.

Superior Coriolis flow sensor

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, Coriolis forces cause a variable phase shift, which is detected by sensors and fed into the integrally mounted pc-board. The resulting output signal is strictly proportional to the real mass flow rate. Coriolis mass flow measurement is fast, accurate and inherently bi-directional. The **mini CORI-FLOW™** features density and temperature of the fluid as secondary outputs.

Fields of application

mini CORI-FLOW™ instruments can be applied for both gases and liquids in process fluid measurement or control systems in semiconductor processing, in fuel cell technology, in food, (petro-) chemical and pharmaceutical industries or analytical installations and in liquid dosing systems for micro reactors, amongst many others.

Capacities

Model	smallest range	nominal range	highest range*
M12	0,1...5 g/h	1...100 g/h	2...200 g/h
M13	1...50 g/h	10...1000 g/h	20...2000 g/h
M14	0,03...1 kg/h	0,1...10 kg/h	0,3...30 kg/h

* Maximum capacities depend on the available pressure difference across the mass flow meter, especially when used on gases. See diagrams and tables on pages 6 and 7 of this brochure.

Features

- > direct mass flow measurement, independent of fluid properties
- > high accuracy, excellent repeatability
- > multi-range: easy on site re-ranging via digital interface (effective turndown 2000:1, typical M13)
- > IP65 design, optional ATEX approval Cat.3, Zone 2
- > metal-sealed construction
- > optional bi-directional measurement
- > additional density and temperature outputs
- > standard analog 0...5(10) Vdc and 0(4)...20 mA and digital communication
- > optional fieldbus interface (DeviceNet™, PROFIBUS DP, Modbus-RTU or FLOW-BUS)
- > alarm and (batch) counter functions



M13 Mass Flow Meter



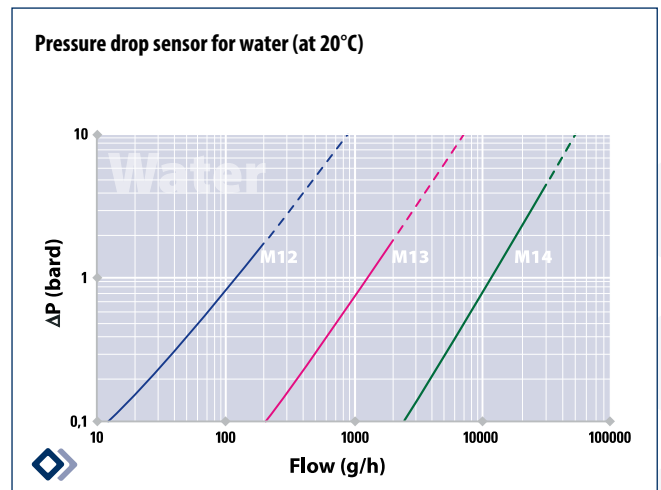
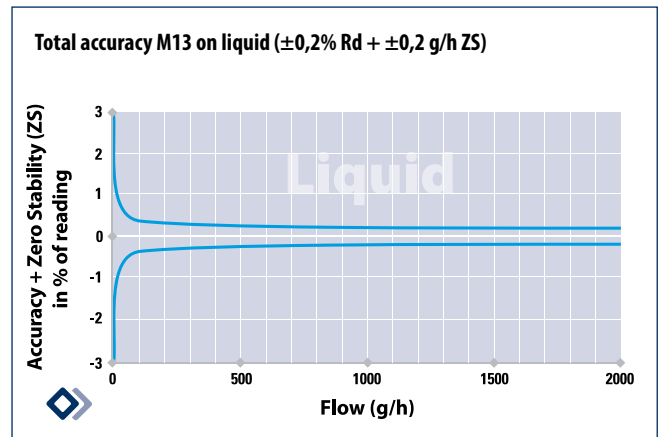
mini CORI-FLOW™ Mass Flow Meter with local readout module, mounted on an optional heavy mass body

Application on liquids

mini CORI-FLOW™ can be applied for most liquid types. The mass flow meters are fully metal sealed, controllers have a high performance elastomeric valve seat, made of Kalrez®.

High accuracy

Coriolis flow meters are unmatched in accuracy. When applied for liquids, the mass flow accuracy is better than $\pm 0,2\%$ Rd. The trumpet graph below illustrates the total mass flow accuracy of an M13 Mass Flow Meter used on liquid.



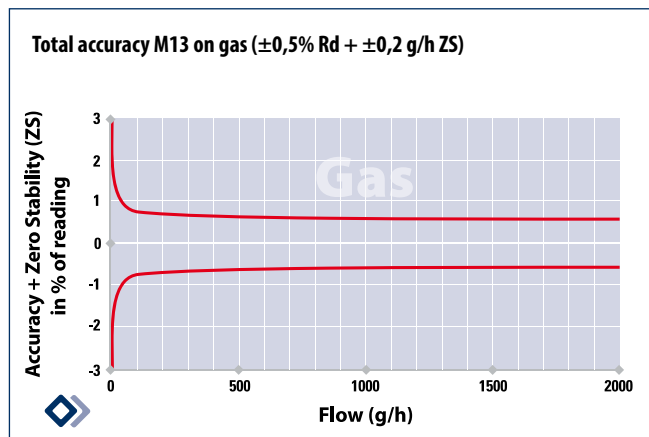
mini CORI-FLOW™ Mass Flow Meters

Application on gases

In comparison with thermal mass flow devices, the Coriolis measuring principle offers the following advantages:

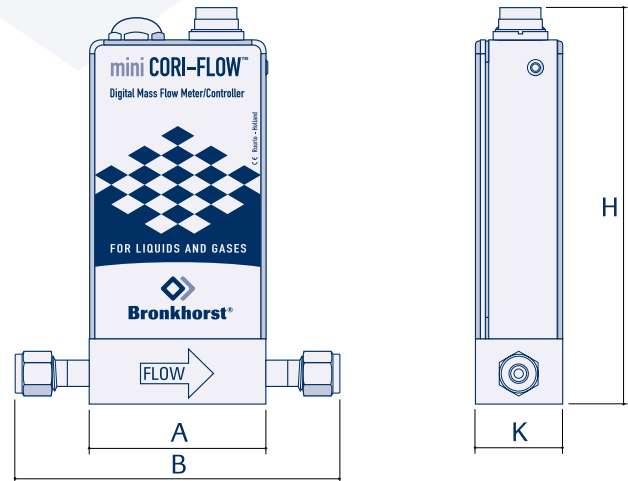
- no conversion factors (if scaled in units of weight)
- possibility to measure unknown fluids or variable mixtures
- can measure (super-) critical gases
- superior accuracy and response time

For gas flow applications, the mass flow accuracy is better than $\pm 0,5\%$ Rd. The trumpet graph below illustrates the total mass flow accuracy of an M13 Mass Flow Meter used on gas.



When engineering your process system for gases consideration must be given to the pressure drop across the flow meter and its associated piping. The tables on the next page illustrate the maximum flow rates for **mini CORI-FLOW™** Mass Flow Meters as a function of the inlet pressure (P1) for a number of common gases.

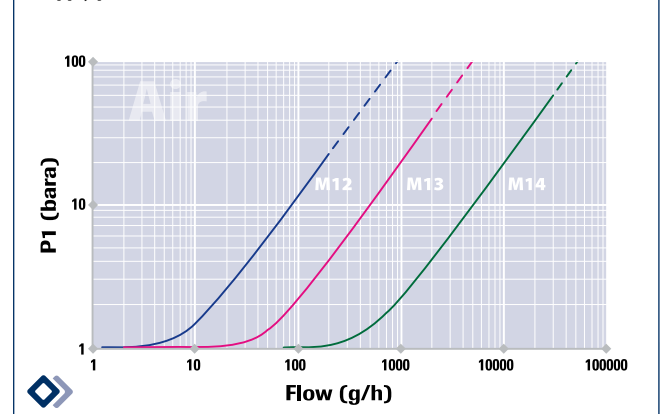
Dimensions Mass Flow Meter



Model	A	B	H	K
M12/M13/M14 (1/4" OD)	64	118	144	32
M12/M13/M14 (1/8" OD)	64	115	144	32
M12/M13/M14 (1/4" VCR)	64	106	144	32

Dimensions in mm

Supply pressure sensor for air (P2 = 1 bara, T = 20°C)



Approx. maximum gas flow rates as function of various inlet pressures

(P2 = 1 bara and T = 20°C)

M12 Mass Flow Meter																				
Gas	Air/N ₂		Ar		CO ₂		CO		C ₂ H ₆		He		H ₂		CH ₄		N ₂ O		O ₂	
	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min
P1 (bara)																				
2	15	0,2	18	0,2	19	0,2	15	0,2	16	0,2	6	0,5	4	0,7	11	0,3	19	0,2	17	0,2
3	25	0,3	30	0,3	30	0,3	24	0,3	25	0,3	9	0,8	6	1,2	18	0,4	30	0,3	26	0,3
5	42	0,5	50	0,5	51	0,4	41	0,5	43	0,5	15	1,4	11	2,0	31	0,7	51	0,4	42	0,5
10	80	1,0	100	1,0	105	1,0	85	1,2	85	1,0	30	3,0	22	4,0	65	1,5	105	1,0	90	1,0
20	168	2,2	200	1,8	200	1,7	166	2,2	172	2,1	63	5,8	44	8,2	125	2,9	200	1,7	177	2,1
50	200	2,6	200	1,8	200	1,7	200	2,7	liquid	liquid	157	15,0	111	20,0	200	4,6	200	1,7	200	2,3
100	200	2,6	200	1,8	liquid	liquid	200	2,7	liquid	liquid	200	19,0	200	37,0	200	4,6	liquid	liquid	200	2,3
200	200	2,6	200	1,8	liquid	liquid	200	2,7	liquid	liquid	200	19,0	200	37,0	200	4,6	liquid	liquid	200	2,3

M13 Mass Flow Meter																				
Gas	Air/N ₂		Ar		CO ₂		CO		C ₂ H ₆		He		H ₂		CH ₄		N ₂ O		O ₂	
	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min
P1 (bara)																				
2	66	0,8	78	0,7	82	0,7	65	0,9	68	0,8	25	2,3	18	3,2	50	1,1	82	0,7	70	0,8
3	105	1,3	124	1,2	130	1,1	104	1,4	108	1,3	39	3,7	28	5,2	78	1,8	130	1,1	111	1,3
5	180	2,3	212	2,0	223	1,9	177	2,4	185	2,3	67	6,3	48	8,8	134	3,1	223	1,9	189	2,2
10	364	4,7	428	4,0	450	3,8	358	4,8	373	4,6	135	12,6	96	17,8	271	6,3	450	3,8	329	4,5
20	730	9,4	857	8,0	903	7,6	718	9,6	747	9,2	271	25,3	193	35,7	544	12,6	903	7,6	767	9,0
50	1826	23,5	2000	19,0	2000	17,0	1796	24,0	liquid	liquid	679	63,3	482	89,3	1360	31,6	2000	17,0	1920	22,4
100	2000	27,0	2000	19,0	liquid	liquid	2000	27,0	liquid	liquid	1357	126,7	963	178,5	2000	46,0	liquid	liquid	2000	23,0
200	2000	27,0	2000	19,0	liquid	liquid	2000	27,0	liquid	liquid	2000	187,0	1926	357,1	2000	46,0	liquid	liquid	2000	23,0

M14 Mass Flow Meter																				
Gas	Air/N ₂		Ar		CO ₂		CO		C ₂ H ₆		He		H ₂		CH ₄		N ₂ O		O ₂	
	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min	g/h	l _v /min
P1 (bara)																				
2	880	11	1040	10	1090	9	865	11	900	11	325	30	230	43	660	15	1090	9	925	11
3	1400	20	1600	15	1700	14	1380	20	1400	17	500	45	370	70	1050	25	1750	15	1480	18
5	2400	30	2800	26	2960	25	2350	31	2450	30	890	83	630	120	1780	41	2960	25	2510	30
10	4750	63	5700	53	6000	50	4750	63	4950	61	1800	168	1280	240	3600	83	6000	50	5100	60
20	9700	125	11400	106	12000	100	9530	127	9900	122	3600	336	2550	470	7220	168	12000	100	10200	120
50	24200	310	28500	270	30000	250	23800	318	liquid	liquid	9010	840	6400	1180	18060	420	30000	250	25500	300
100	30000	387	30000	280	liquid	liquid	30000	400	liquid	liquid	18020	1680	12800	2370	30000	700	liquid	liquid	30000	350
200	30000	387	30000	280	liquid	liquid	30000	400	liquid	liquid	30000	2800	25600	4740	30000	700	liquid	liquid	30000	350

Notes:

- (1) For all gas flow values the measuring error is $\pm 0,5\% Rd \pm$ zero stability
- (2) "Liquid": Fluid will be in liquid phase under certain conditions: not recommended; phase changes in instrument should be avoided!
- (3) For a gas flow meter the maximum flow will decrease with increasing back pressure.
- (4) For a gas flow controller the maximum flow under the same operating conditions will be approx. 0,75 times the indicated flow rate for a meter.
For example: The maximum flow through an M13 meter only at P1=10 bara and P2=1 bara at 20°C is approx. 475 g/h or 6,3 l_v/min Air.
 Under the same conditions the maximum flow through an M13 controller is approx. 0,75 * 475 = 356 g/h or 4,7 l_v/min.
- (5) To control the same amount of gas indicated in the table, please raise the inlet pressure (P1) by 33% (divide P1 by 0.75).
For example: To control 475 g/h or 6,3 l_v/min Air the inlet pressure should be increased from 10 bara to 13,3 bara (at P2 = 1 bara and T=20°C)

mini CORI-FLOW™ Mass Flow Controllers

General

The pc-board of a **mini CORI-FLOW™** Mass Flow device features integrated, adaptable PID control for fast and smooth control of any electronically driven control valve. Depending on the application this could be an integrated direct acting valve or a separately mounted valve for special tasks, e.g. a pressure actuated control valve. Integrated control valves for liquid applications have a purge connection on top of the sleeve that enables easy elimination of air or gas when starting up the system. For liquid dosing Bronkhorst® offers an alternative way to control the flow. Instead of using a control valve, the Coriolis flow meter can be combined with a gear pump, thus eliminating the need of pressurising the liquid source.

Alternative to Thermal Gas Mass Flow Controllers

Compared to traditional thermal MFCs, Coriolis based flow controllers offer better accuracy and independence of fluid properties. There are no moving parts or obstructions in the flow path. Furthermore the Coriolis sensor is by nature faster than a sensor based on heat transfer.

mini CORI-FLOW™ flow controllers have the same footprint as typical thermal MFCs for equivalent flow ranges. Also electrically the instruments feature the same analog (0-5 Vdc / 4-20 mA) and digital (RS232) outputs as a standard, with optional interface to PROFIBUS DP, DeviceNet™, Modbus-RTU or FLOW-BUS. The enclosure of the Mass Flow Controller is rugged, weatherproof (IP65) and available with optional ATEX approval for use in Zone 2 hazardous areas. The PN100 rated control valves are available in normally closed (nc) and normally open (no) configurations.

Integrated control valve options:

- V10I: Gas flow control valve (nc)
- V11I: Gas flow control valve (no)
- V14I: Liquid flow control valve (nc)

Capacities

Model	smallest range	nominal range	highest range*
M12V1NI	0,1...5 g/h	2...100 g/h	4...200 g/h
M13V1NI	1...50 g/h	20...1000 g/h	40...2000 g/h
M14V1NI	0,03...1 kg/h	0,2...10 kg/h	0,6...30 kg/h

* The maximum capacities depend on the available pressure difference, especially when used on gases (see page 7).

Fields of applications

mini CORI-FLOW™ Meters/Controllers are suitable for applications in industrial environment (incl. optional ATEX Cat.3 Zone 2), laboratories and OEM installations in the following markets (typically):

- > pilot plants
- > fuel cell technology
- > semiconductor processing
- > food & pharmaceutical industries
- > analytical installations
- > liquid dosing systems for micro reactors
- > plasma surface technology
- > (petro-) chemical industries

Features

In addition to the features already mentioned for the Mass Flow Meters, **mini CORI-FLOW™** Controllers offer:

- > fast and stable control
- > integrated electronics with PID controller
- > very compact design: same footprint as thermal MFC
- > metallic outer seals; Kalrez® plunger seat



M14V14I Mass Flow Controller

mini CORI-FLOW™ Mass Flow Controllers

Pressure drop Mass Flow Controllers

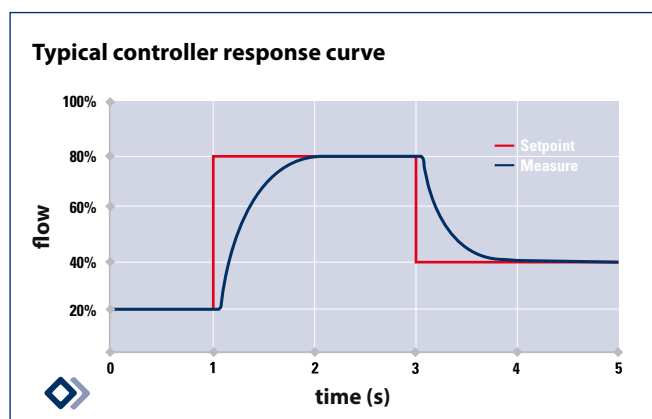
As a rule of thumb the pressure difference (ΔP) across the control valve should be at least 50% of the total ΔP across the system for liquid applications, for gases preferably even higher (approx 75%).

Close-coupled control valves

For control applications normally an MFC with integrated control valve will be preferred, because it is the most compact and economical solution. Sometimes, however, a separate control valve could be more practical or offer technical advantages. This could be a standard direct acting, electro magnetic control valve or, for instance, a pilot operated valve for applications with high differential pressure.

Control performance

mini CORI-FLOW™ Mass Flow Controllers feature a highly stable control output and fast response; see depicted response curve with some typical setpoint changes.

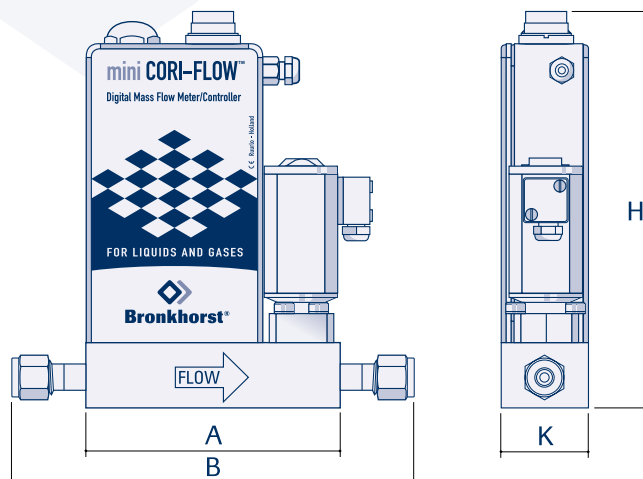


Thanks to the extremely fast sensor (50...200 msec) it is possible to achieve very fast control e.g. for dosing applications. Contact your local distributor for more information.

Mass Flow Meter with pressure actuated control valve



Dimensions Mass Flow Controller



Model	A	B	H	K
M12V1NI/M13V1NI/M14V1NI (1/4" OD)	92	146	144	32
M12V1NI/M13V1NI/M14V1NI (1/8" OD)	92	143	144	32
M12V1NI/M13V1NI/M14V1NI (1/4" VCR)	92	124	144	32

Dimensions in mm

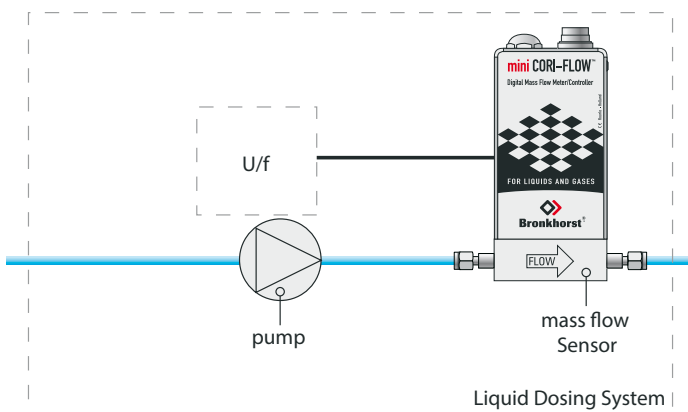
mini CORI-FLOW™ Liquid Dosing Systems, using flow meter controlled pumps

An alternative way of control

In some applications it is not possible or not recommended to use a control valve, for instance when a vessel with liquid cannot be pressurised. As an alternative, Bronkhorst® can offer virtually pulse-free gear pumps, HPLC or diaphragm pumps, close-coupled to the Coriolis flowmeter.

Liquid dosing system

A **mini CORI-FLOW™** liquid dosing system consists of a Coriolis flow meter, a gear pump and interconnecting material. Furthermore Bronkhorst® will take care of electrical and mechanical connection, testing and, if possible optimisation including the PID-integrated controller.



A complete series of pumps is available for very small through to higher flow rates, for higher pressures and for aggressive fluids. Further to operation in analog mode, the Liquid Dosing System can also be used digitally with RS232 or with an on-board fieldbus interface. Due to easy re-ranging of the instrument via digital interface, control ranges can be increased up to 1:2000!

Features

- > simple and compact assembly; easy to use
- > no need to pressurise liquid source
- > pump controlled by mass flow instrument with adjustable PID-controller via voltage output signal
- > complete dosing system with small dimensions
- > direct mass flow measurement/control (not volumetric)
- > high accuracy and stability (nearly pulse free)
- > response alarm to protect pump against damage due to running dry
- > desired flow to be set via: analog 0...5(10) V / 0(4)...20 mA or digital communication by RS232, PROFIBUS DP, DeviceNet™, Modbus-RTU or FLOW-BUS



Liquid dosing system consisting of a **mini CORI-FLOW™** Mass Flow Meter, close-coupled to a gear pump.

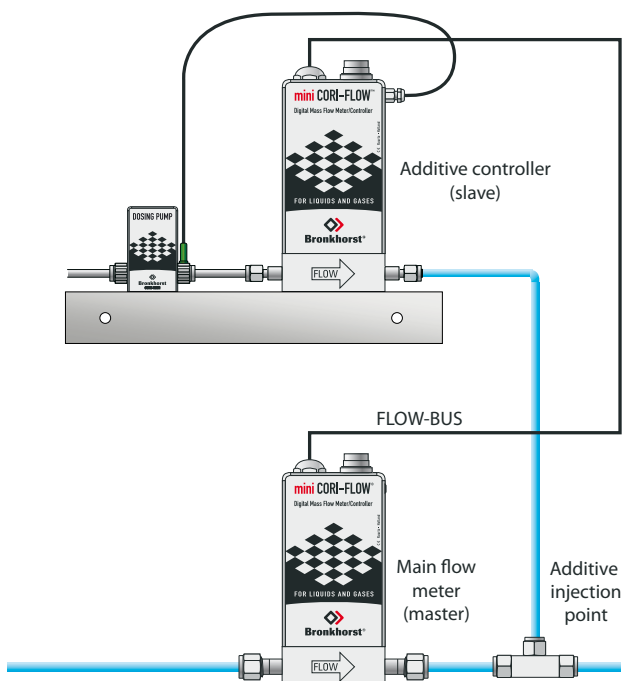
mini CORI-FLOW™ Applications

Gas or liquid precursor delivery

In deposition processes various precursor fluids must be accurately controlled, either in gas phase or as a liquid. The high precision Mass Flow Controllers of the **mini CORI-FLOW™** series are particularly suitable for these demanding applications. Thanks to the “multi-range” feature, Original Equipment Manufacturers (OEM customers) are able to drastically reduce the variety of spare instruments and thus the cost of ownership, since the instruments are easy to re-range.

mini CORI-FLOW™ for additive dosage

Many applications ask for compact, accurate measurement and control of additives to be proportionally dosed into a main flow. By using **mini CORI-FLOW™** instruments it is easy to set up compact, autonomous working systems that offer this functionality without the need of external computer hard- and software. In the setup below, the master flow meter measures the main flow and is connected to FLOW-BUS (a Bronkhorst® fieldbus). The slave instrument, which has been pre-set to follow the master with a certain ratio, is also connected to FLOW-BUS.

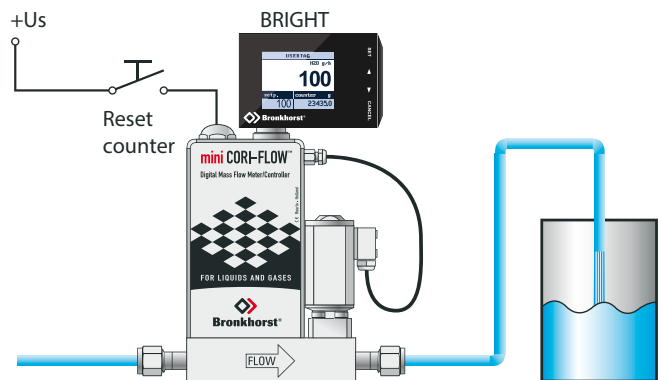


Ratio control: slave follows master with adjustable ratio

As a result of a variable main flow, the slave-instrument responds to the changed master output signal, received via FLOW-BUS. The slave-instrument will re-calculate its setpoint. The pump with integrated U/f converter translates the PID-controller output voltages into rotation speed to reach the desired flow rate.

mini CORI-FLOW™ used as a batch counter

The **mini CORI-FLOW™** instrument measures the flow rate and the integrated PID-controller drives a proportional valve. The flow rate setpoint can be provided using the **mini CORI-FLOW's** analog input or via digital communication interfaces (RS232 or fieldbus). The desired batch can be programmed into the integrated counter limit value. After each batch, the flowmeter can be reset using the button on the instrument, via an external switch or via the digital interface. Each time when the counter limit (batch) has been reached, the **mini CORI-FLOW™** will close the valve until the next reset. These integrated digital features enable the user to define a highly accurate, fast, repeatable and compact batching/dosing system. For ultra-fast batching it is also possible to use a shut-off valve in combination with a needle valve for flow limitation.



Batch control with optional local Readout/Control module

mini CORI-FLOW™ Applications

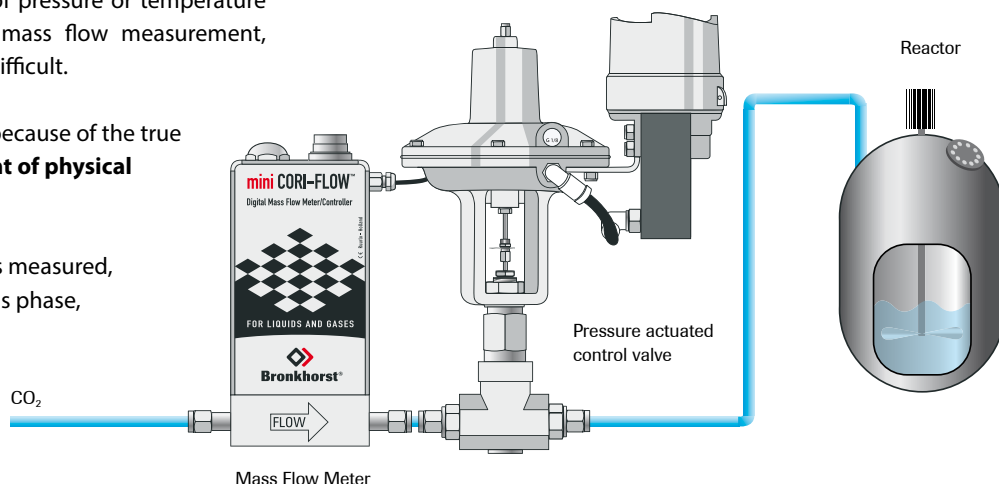
Supercritical gas measurement and control

Fluids like carbon dioxide (CO₂) are difficult to measure when they move towards the inter-phase stage between being a liquid and a gas. For example, for CO₂ this occurs at temperatures >31,1°C and pressures higher than approx. 73,8 bara. Under these conditions, physical properties like density (ρ) and heat capacity (Cp) change very rapidly as a result of pressure or temperature variations. This makes an accurate mass flow measurement, based on the thermal principle, very difficult.

mini CORI-FLOW™ offers a solution here because of the true mass flow measurement, **independent of physical properties.**

The **true** mass flow of the molecules is measured, regardless of whether the fluid is in gas phase,

in liquid phase or indeed somewhere in between. Experiences in the field have proven that this principle of measuring is very accurate and reliable. For control applications Bronkhorst® can offer a flow meter in combination with a metal sealed, pressure actuated control valve. Please contact factory for a customised advice.



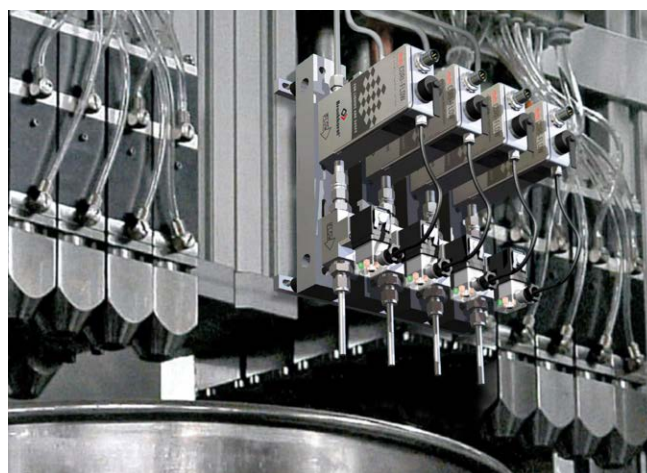
mini CORI-FLOW™ with pressure actuated control valve

CORI-FILL™: Compact Fluid Dosing Assemblies

Each Compact Fluid Dosing Assembly consists of a Coriolis Mass Flow Meter of the **mini CORI-FLOW™** or **CORI-FLOW™** series and a valve or a (gear) pump. The onboard PID-controller of the flow meter will be optimized for controlling the valve or the (gear) pump and enables an immediate start of dosage after connecting power and fluid accessories. Just enter the desired flow or batch at the operation module (or remotely by computer) and the compact unit will dose true mass flow, for example independent of ambient temperature and back pressure. Using the integrated **CORI-FILL™** technology, the Coriolis meter's totalizer is capable of highly accurate batch dosage. It also ensures the actuator will react as soon as the batch has been reached. Normally several components would be needed to achieve this:

- flowmeter
- valve/pump
- batchcounting module/PLC
- software handling these items

CORI-FILL™ offers all this functionality in one component, in one assembly and from one supplier, without the need of complex programming of additional hardware.



Applications

CORI-FILL™ has been successfully applied for dosage of additives, fragrances, flavours, colourants and sterilization fluid (H₂O₂)

See separate brochure downloadable at: www.cori-fill.com

Technical specifications

Flow ranges

	Unit	M12	M13	M14
Minimum full scale	[g/h]	5	50	1000
Nominal flow	[g/h]	100	1000	10000
Maximum full scale	[g/h]	200	2000	30000
Minimum flow	[g/h]	0,1	1	30
Rangeability meter		1:100	1:100	1:100
Rangeability controller		≥ 1:50	≥ 1:50	≥ 1:50

Mechanical parts

Material (wetted parts)	Stainless steel AISI 316L or equivalent Optional: Hastelloy-C22
Process connection	Compression type (welded) or face seal couplings
Outer seals	Metal
Valve seat (controllers)	Kalrez®-6375, other on request
Weight	Meter: 1,2 kg; Controller: 1,7 kg
Ingress protection	IP65 (weatherproof)
Leak integrity	Outboard < 2 x 10 ⁻⁹ mbar l/s He
Pressure rating	Meter: 200 bar*; Compact controller: 100 bar* Separate valve up to 200 bar*

* Higher on request.

Performance

Mass flow accuracy liquids	±0,2% of rate			
Mass flow accuracy gases	±0,5% of rate			
Repeatability (based on digital output)	±0,05% of rate ±1/2 [ZS x 100/flow]% (ZS = Zero Stability)			
<i>Note: optimal accuracy will be reached after approx. 30 minutes after instrument power-up.</i>				
	Unit	M12	M13	M14
Zero stability (ZS)*	[g/h]	< 0,02	< ±0,2	< ±6
Density accuracy	[kg/m ³]	< ±5	< ±5	< ±5
Temperature accuracy	[°C]	±0,5	±0,5	±0,5
Temperature effects				
Zero drift	[g/h/°C]	±0,01	±0,02	±0,5
Span drift	[%Rd./°C]	±0,001	±0,001	±0,001
Initial heating at zero flow	[°C]	≤ 15 **	≤ 15 **	≤ 15 **
* The zero stability is guaranteed at constant temperature and for unchanging process and environment conditions.				
** Total heating up of instrument depends on flow rate, heat capacity fluid, T amb., T fluid and cooling capacity.				
Mounting	In any position (attitude sensitivity negligible)***			
Device temperature	0 ...70°C; for ATEX Cat.3, Zone 2 max. 50°C			
Typical meter response time (t98%)	0,2 s			
Typical settling time controller (<2% of setpoint)	1 s			
*** In order to guarantee the zero stability the instrument needs to be rigidly bolted to a stiff and heavy mass or construction. External shocks or vibrations should be avoided. Instruments mounted closely together need to be rigidly bolted to separate stiff and heavy masses or constructions to avoid interference (cross-talk).				

Technical specifications

Electrical properties

Power supply	+15...24 Vdc \pm 10% Max. ripple recommended: 50 mV tt
Power consumption	Meter: 3 W; Controller: max. 7 W
Analog output / command	0...5 (10) Vdc or 0 (4)...20 mA (sourcing output)
Digital communication	Standard: RS232 Options: PROFIBUS DP, DeviceNet™, Modbus-RTU, FLOW-BUS
Electrical connection	
Analog/RS232	8-pin DIN male;
PROFIBUS DP	bus: 5-pin M12 female; power: 8-pin DIN male;
DeviceNet™/Modbus-RTU/ FLOW-BUS	5-pin M12 male

Calibration

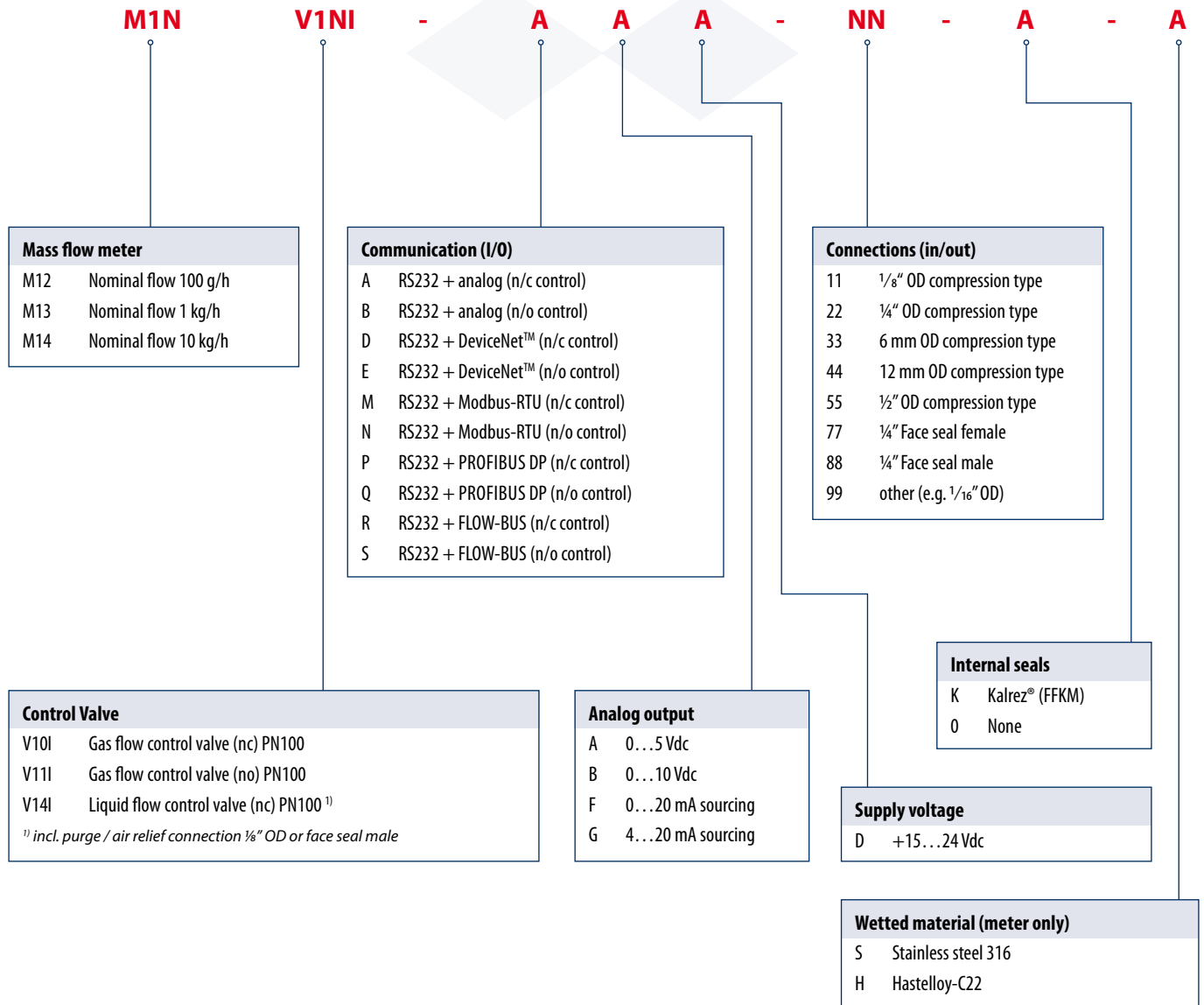
References	Traceable to Dutch and international standards
Calibration fluid	Multi-range calibration on H ₂ O

Specifications are based on reference conditions of 20°C. Technical specifications subject to change without notice



Mass Flow Meter with electro magnetic control valve

Model number identification





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mini CORI-FLOW™ M15

Compact Coriolis Mass Flow Meters & Controllers for Liquids and Gases

General

Coriolis mass flow meters are highly appreciated for their accuracy and independence of fluid properties. The direct Coriolis mass flow measuring principle is generally used for higher flow rates. However, Bronkhorst® has succeeded in applying this technique for low to very low flows. Moreover, **mini CORI-FLOW™** instruments have an integrated PID-controller and a batch counter to control the fluid flow.

mini CORI-FLOW™ model M15

In addition to the previously developed **mini CORI-FLOW™** series M12-M14 for ranges from 0,1 g/h up to 30 kg/h, Bronkhorst® developed the new model M15 for mass flow rates between 0,2 and 300 kg/h. Similar to the models for lower flow rates, M15 contains a uniquely shaped, single loop sensor tube, forming part of an oscillating system. When a fluid flows through the tube, Coriolis forces cause a variable phase shift, which is detected by sensors and fed into the integrally mounted pc-board.

The resulting output signal is strictly proportional to the real mass flow rate. All instruments of the **mini CORI-FLOW™** series feature density and temperature of the fluid as secondary outputs. Furthermore the instruments offer "scalable range" functionality: factory calibrated ranges can be rescaled by the user, maintaining the original accuracy specs. As a result of this, customers are able to reduce the variety of instruments and thus reduce the cost of ownership. The instruments are equipped with a robust IP65 weatherproof housing and are available with optional ATEX approval for use in Zone 2 hazardous areas.

Fields of application

mini CORI-FLOW™ instruments can be applied for both gases and liquids in process fluid measurement or control systems in (petro-) chemical and pharmaceutical industries, food & beverage applications and liquid dosing systems in a wide variety of markets.



mini CORI-FLOW™ M15 Mass Flow Meter

Features

- > direct flow measurement, independent of fluid properties
- > integrated PID controller for control valve or pump
- > CORI-FILL™ batch dosing functionality
- > fast response time
- > high accuracy, excellent repeatability
- > additional density and temperature outputs
- > compact design (same footprint as CORI-FLOW™ M50 series)
- > excellent price/performance ratio
- > scalable range: easy on site re-ranging via digital interface (large rangeability)
- > no dead volume (single, uninterrupted tube)
- > insensitive for environment vibrations
- > analog I/O-signals, RS232-connection, optional on-board fieldbus interface
- > IP65 design, optional ATEX approval Cat.3, Zone 2

Technical specifications

Flow ranges

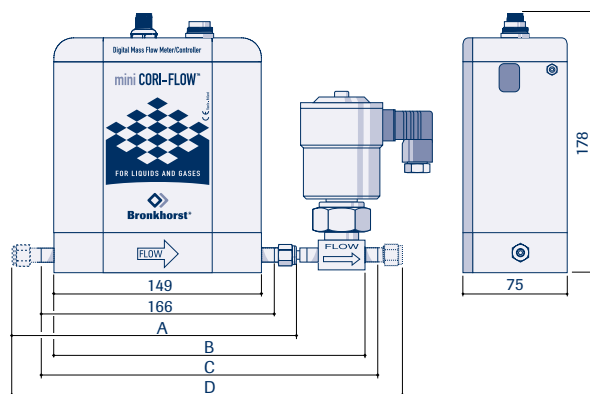
	Unit	M15
Minimum flow	[g/h]	200
Minimum full scale	[kg/h]	5
Nominal flow*	[kg/h]	100
Maximum full scale	[kg/h]	300
Rangeability meter		1:100
Rangeability controller		≥ 1:50

* $\Delta p = 1 \text{ bar}$ for H_2O

Mechanical parts

Material (wetted parts)	Stainless steel AISI 316 or equivalent; Other materials on request
Process connection	Compression type or face seal couplings (welded)
Outer seals	Metal
Weight	Meter: approx. 5 kg; Controller: on request
Ingress protection	IP65 (weatherproof)
Leak integrity	Outboard $< 2 \times 10^{-9}$ mbar l/s He
Pressure rating	100 bar

Dimensions Mass Flow Meter/Controller



The valve in this drawing is the CSI. Other valves have different shapes.

Model (values in mm)	A	B	C	D
M15 (1/4" OD)	204	-	-	-
M15 (1/4" VCR)	203	-	-	-
M15+C0I (1/4" OD)	204	219	236	274
M15+C0I (1/4" VCR)	203	219	236	271
M15+C2I (1/4" OD)	204	219	236	274
M15+C2I (1/4" VCR)	203	219	236	271
M15+C5I (1/4" OD)	204	219	236	274
M15+C5I (1/4" VCR)	203	219	236	271
M15+F033CI (1/4" OD)	204	283	n/a	338
M15+F004AI (1/4" OD)	204	270	n/a	326
M15+F004AI (1/4" VCR)	203	270	n/a	319

For other models contact factory.

Electrical properties

Power supply	+15...24 Vdc $\pm 10\%$ Max. ripple recommended: 50 mV tt
Power consumption	Meter: 3 W; Controller: max. 7 W
Analog output / command	0...5 (10) Vdc or 0 (4)...20 mA (sourcing output)
Digital communication	Standard: RS232 Options: PROFIBUS DP, DeviceNet™, Modbus-RTU, FLOW-BUS
Electrical connection	
Analog/RS232	8-pin DIN male;
PROFIBUS DP	bus: 5-pin M12 female; power: 8-pin DIN male;
DeviceNet™/Modbus-RTU/ FLOW-BUS	5-pin M12 male

Performance

Mass flow accuracy liquids	$\pm 0,2\%$ of rate
Mass flow accuracy gases	$\pm 0,5\%$ of rate
Repeatability (based on digital output)	$\pm 0,05\%$ of rate + [ZS x 100/flow]% (ZS = Zero Stability)

Note: optimal accuracy will be reached after approx. 30 minutes after instrument power-up.

The indicated accuracies are based on mass flow (e.g. g/h, kg/h, etc.). If the instrument will be used on volume flow (e.g. l/h, ml/min, etc) this will introduce an extra inaccuracy, based on the density (measurement).

	Unit	M15
Zero stability (ZS)*	[g/h]	$< \pm 50$
Density accuracy	[kg/m ³]	$< \pm 5$
Temperature accuracy	[°C]	$\pm 0,5$
Initial heating at zero flow	[°C]	$\leq 10^{**}$

* The zero stability is guaranteed at constant temperature and for unchanging process and environment conditions.

** Total heating up of instrument depends on flow rate, heat capacity fluid, T amb., T fluid and cooling capacity.

Mounting	In any position (attitude sensitivity negligible)***
Device temperature	0...70°C; for ATEX Cat.3, Zone 2 max. 50°C
Typical meter response time ($\tau_{98\%}$)	0,2 s
Typical settling time controller (<2% of setpoint)	1 s

*** External shocks or vibrations should be avoided.

Note: Technical specifications in this brochure subject to change without notice.

Mass Flow Meter

Capacities

Model	smallest range	nominal range	highest range*
M15	0,2...5 kg/h	1...100 kg/h	3...300 kg/h

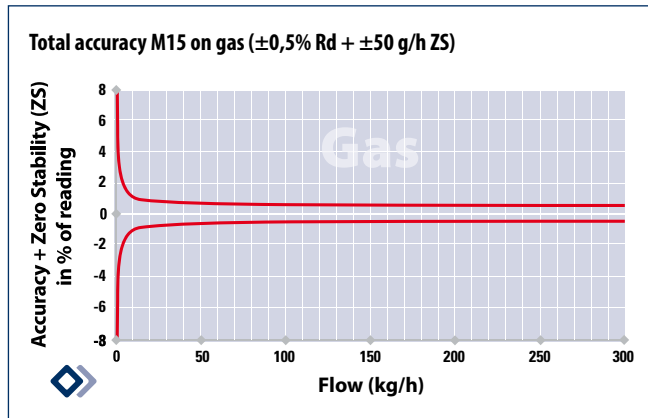
*Maximum capacities depend on the available pressure difference across the mass flow meter, especially when used on gases.

Application on gases

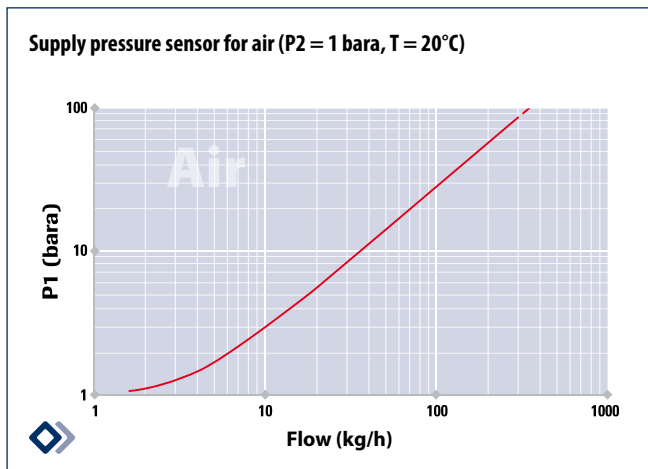
In comparison with thermal mass flow devices, the Coriolis measuring principle offers the following advantages:

- no conversion factors (if scaled in units of weight)
- possibility to measure unknown fluids or variable mixtures
- can measure (super-) critical gases
- superior accuracy and response time

For gas flow applications, the mass flow accuracy is better than $\pm 0,5\%$ Rd. The trumpet graph below illustrates the total mass flow accuracy of an M15 Mass Flow Meter used on gas.



When engineering your process system for gases consideration must be given to the pressure drop across the flow meter and its associated piping.



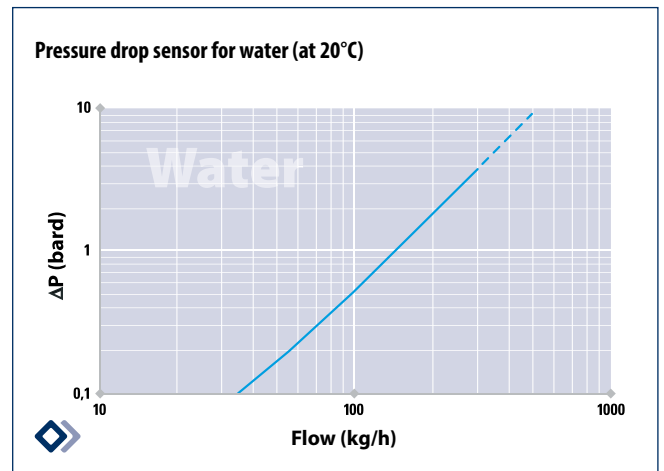
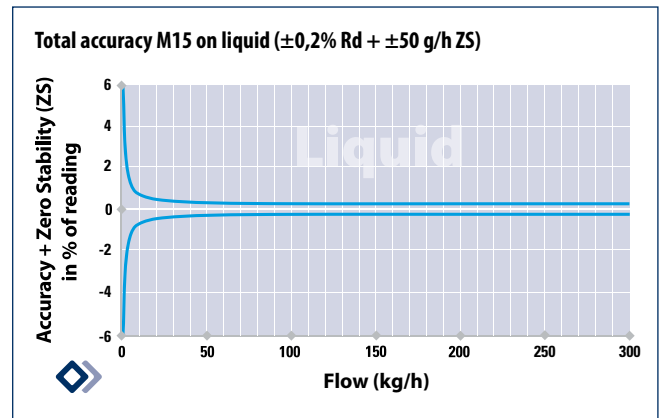
Application on liquids

mini CORI-FLOW™ can be applied for most liquid types. The mass flow meters are fully metal sealed, controllers have a high performance elastomeric valve seat, made of Kalrez.

High accuracy

Coriolis flow meters are unmatched in accuracy. When applied for liquids, the mass flow accuracy is better than $\pm 0,2\%$ Rd.

The trumpet graph below illustrates the total mass flow accuracy of an M15 Mass Flow Meter used on liquid.



Calibration

References

Verified by NKO, the Dutch calibration organisation, and VSL traceable to Dutch and international standards

Calibration fluid

Multi-range calibration on H₂O

Specifications are based on reference conditions of 20°C. Technical specifications subject to change without notice

Mass Flow Controller

Close-coupled control valves

For control applications M15 **mini CORI-FLOW™** meters offer integrated, adaptable PID control for fast and smooth control of close-coupled control valves. This could be a standard direct acting, electro magnetic control valve or, for instance, a pilot operated valve for applications with high differential pressure.

Close-coupled control valve options:

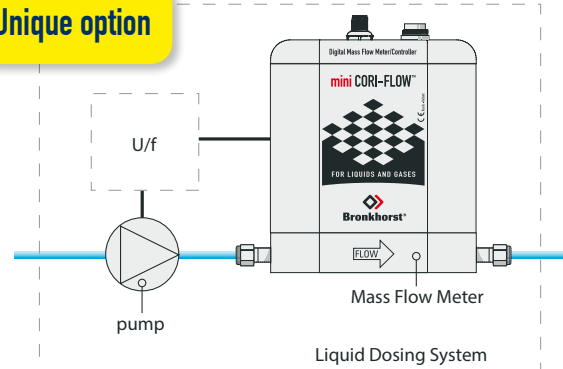
M15+C01: Gas flow control valve (nc), $K_v\text{-max}=6,6 \times 10^{-2}$
M15+C21: Liquid flow control valve (nc), $K_v\text{-max}=2,3 \times 10^{-3}$
M15+C51: Gas/Liquid flow control valve (nc), $K_v\text{-max}=6,6 \times 10^{-2}$
M15+F-004A1: Gas/Liquid flow control (nc), $K_v\text{-max}=3,0 \times 10^{-1}$
M15+F-004B1: Gas/Liquid flow control (nc), $K_v\text{-max}=1,0$

Bronkhorst® can also offer a mass flow meter in combination with pressure actuated control valves, supplied by a third party. Please contact factory for a customised advice.

Mass flow control with pumps

In some applications it is not possible or not recommended to use a control valve, for instance when a vessel with liquid cannot be pressurised. As an alternative, Bronkhorst® can offer virtually pulse-free pumps, close-coupled to the Coriolis flow meter.

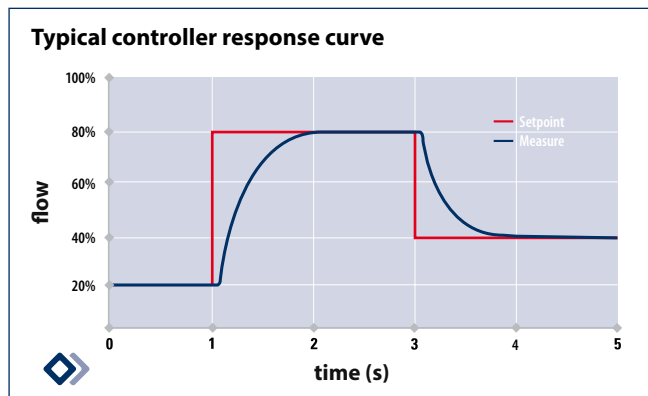
Unique option



mini CORI-FLOW™ incorporates PID control as standard

Control performance

mini CORI-FLOW™ Mass Flow Controllers feature a highly stable control output and fast response; see depicted response curve with some typical setpoint changes.



Thanks to the extremely fast sensor (50...200 msec) it is possible to achieve very fast control e.g. for dosing applications. Contact your local distributor for more information.

Pressure drop Mass Flow Controllers

As a rule of thumb the pressure difference (ΔP) across the control valve should be at least 50% of the total ΔP across the system for liquid applications, for gases preferably even higher (approx 75%).

Batch dosing with proportional valves and pumps

mini CORI-FLOW™ instruments are capable of operating with proportional valves or (gear) pumps using the integrated PID-controller. Thanks to **CORI-FILL™** technology, all batch counters now have an extra P-controller to make the valve close or make the pump stop smoothly as soon as the batch total is reached.

When using shut-off valves **CORI-FILL™** technology includes an automatic overrun correction on batch dosing. After just a few doses the accuracy will be optimized. Physical delays and pressure disturbances which might cause under- or over-runs will be automatically compensated.

Features

- > "First time right" batch (no overrun correction needed when using a PID controller i.c.w. proportional valves or pumps)
- > Fast dosing < 0,5 seconds (using shut-off valves)
- > Filling accuracy for batchdosing:
 - For liquids: < 0,5%
 - For gases: < 1%

Shut-off valves

mini CORI-FLOW™ instruments are capable of operating with both +24Vdc electric shut-off valves and pneumatic valves. Electric valves can be operated within a special power saving mode to reduce energy consumption and minimize temperature increase thereby reducing the risk of fluid evaporation.

