MASS-STREAM™ D-6400

Mass Flow Meters and Controllers for Gases

Bronkhorst®

MASS-STREAM™
Your best choice for inline flow measurement

Introduction

The thermal Bronkhorst® mass flow meters and controllers for gases based on direct through-flow measurement are produced in Germany since 1997. The MASS-STREAM™ series D-6400 works following the constant temperature anemometer principle.

Our MASS-STREAM™ instruments cover a wide range of measurement and control applications in almost every industry sector - like mechanical engineering and process industry, gas production, food and beverage industry as well as environmental engineering and the chemical industry.

We are committed to a long lasting cooperation with our customers and of course we are also your competent contact for special solutions. You benefit from our well-trained, highly motivated team and our culture of quality.

Please visit our website www.bronkhorst.com to find your local sales partner.

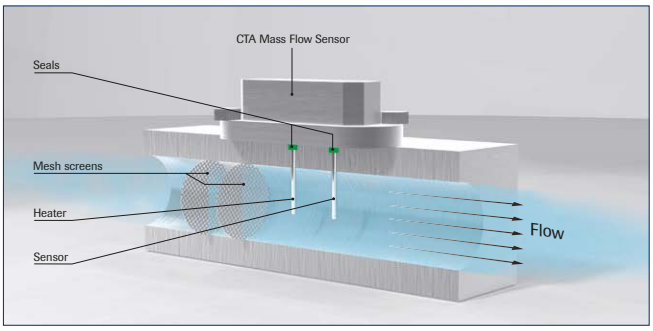
Flow ranges

Smallest standard range	Highest standard range
0,01…0,2 l_n/min (Air)	200…10.000 l_n/min (Air)

Within the above mentioned borders intermediate calibrations with a turn-down ratio up to 1:100 are also possible.
The comprehensive Bronkhorst product range includes a variety of instruments with smaller and higher flow ranges as well as extended standards and tailor-made special solutions.

Principle of through-flow measurement

The mass flow meters and controllers consist of a metal body with a straight through-flow path. Two sensors are encased with stainless steel and protrude inside this bore; one is designed as a heater and the other one is designed as a temperature probe. A constant difference in temperature (ΔT) is created between the two sensors. The heater energy required to maintain this ΔT is dependent on the mass flow. The working principle is based on King's law of the ratio between the mass flow and the heater energy. That means the higher the flow, the more energy is required to maintain the specific ΔT.



Features

- Direct inline measurement principle
- Usable for many gases and gas-mixes
- Mass flow measurement and control for a wide scope of applications
- Many on-board communication options to connect with Ethernet, CAN and other serial fieldbuses
- Precise control mode and good response times
- Compact and robust design
- IP65 for full product range
- Bodies available in aluminium (EN AW-6082-T6) or stainless steel (SS316) for corrosive gases
- Sensor made of stainless steel
- Low sensitivity to dirt and humidity
- Measurement without moving parts
- Modern multi-coloured TFT display
  - IP65 compliant
  - Operator buttons on the instrument
  - Customized adjustable multi-functional display: actual flow, fluid sets, totalizer with memory and reset, alarm, setup and much more
- Compatible with Bronkhorst FlowSuite software
- On-board gas database (FLUIDAT on board)
- Customized input/output options
- Optional connectors (fittings) according to ISO-1179 standard

Applications

- Aeration
- Analytical instruments
- Biogas applications
- Burner / furnace controls
- Coating plant and paint-spray lines
- Exhaust gas and ammonia measurement
- Gas consumption measurement
- Gas monitoring systems
- Gas purging
- Mechanical engineering
- $N_2/O_2/O_3$-generators
- Heat treatment and casting
- and much more

Multi-coloured TFT display

Mass flow meter (MFM) D-64X0
Mass flow controller (MFC) D-64X1, D-64X3

Principle of operation

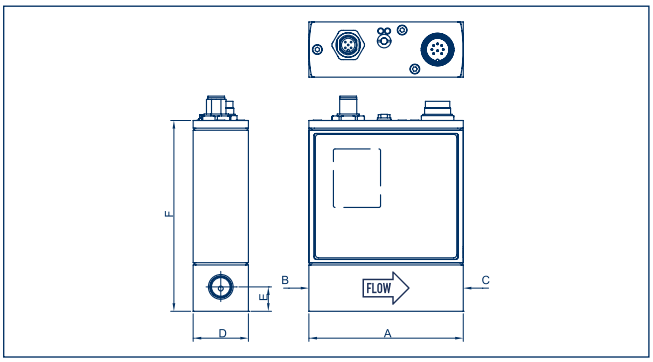
The digital MASS-STREAM™ mass flow meters (MFM) and controllers (MFC) are operated with a main-board with all functions for the flow measurement and control. The instruments can be supplied with commonly used digital or analog input/output signals and when ordering a digital instrument please forward the required presettings. Along with the standard RS232 interface the additional fieldbuses CANopen®, DeviceNet™, EtherCAT®, PROFIBUS DP, PROFINET, Modbus (RTU, ASCII or TCP/IP), EtherNet/IP, POWERLINK and FLOW-BUS are also available. The digital MASS-STREAM™ model series is characterized by a high degree of signal integrity and, as an option, up to 8 calibration curves of different gases and process conditions can be memorized in the instrument. To provide adaptability and flexibility for a wide range of different process conditions our customers are offered the possibility to adjust, to optimize and to evaluate the parameters and control characteristics, even whilst on site.

Bronkhorst supplies compact MASS-STREAM mass flow controllers for flows up to 10.000 l_n/min Air-equivalent with the valve integrated with the instrument body and K_v-values up to 8,2. MASS-STREAM model D-6471/DR3 mass flow controller for 300…3000 l_n/min at low differential pressure (≥ 30 mbar) is described in a separate data sheet. (Additional mass flow controllers with separate control valves on request.)
The accompanying software and documentation is a basic part of our scope of supply as well as the calibration certificate.

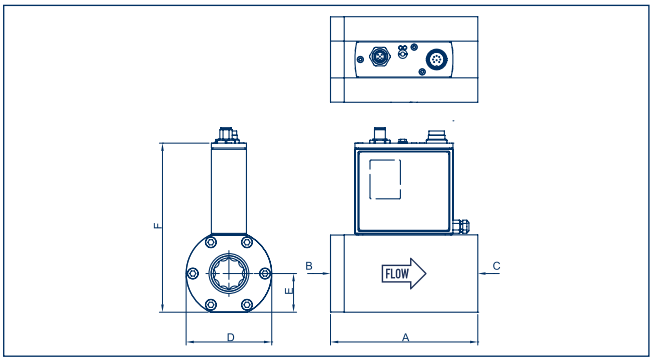
D-6400 dimensions (in mm) and weights (in kg)

Model	A	B*	C*	D	E	F	I	ALU	SS316
D-6410	95	G¼"	G¼"	34	15	117		1,0	1,5
D-6420	95	G¼"	G¼"	34	15	117		1,0	1,5
D-6440	95	G¼"	G¼"	34	15	114		1,0	1,5
D-6460(A)	95	G½"	G½"	34	16	122		1,1	1,6
D-6470	117	G½"	G½"	58	25	136		1,4	2,5
D-6470A	150	G½"	G½"	74	33,5	155		n.a.	2,5
D-6480	143	G1"	G1"	83	37,5	164		2,3	4,9
D-6490	211	G2"	G2"	120	56,3	201		5,5	12,2
D-6411	95	G¼"	G¼"	34	15	117		1,1	1,6
D-6421	95	G¼"	G¼"	34	15	117		1,1	1,6
D-6441	95	G¼"	G¼"	34	15	114		1,1	1,6
D-6461/FAS	110	G½"	G½"	34	16	122		1,2	1,7
D-6461(A)/002BI	145	G½"	G½"	34	16	122	106	1,7	2,2
D-6471/004BI	192	G½"	G½"	65	25	136	186	4,4	6,9
D-6471A/003AI	208	G½"	G½"	74	33,5	155	130	n.a.	6,6
D-6481/003AI	212	G1"	G½"	83	37,5	164	134	n.a.	7,0
D-6481/003BI	236	G1"	G1"	89	42	168	147	n.a.	9,3
D-6491/003BI	304	G2"	G1"	120	56,3	201	161	n.a.	16,0

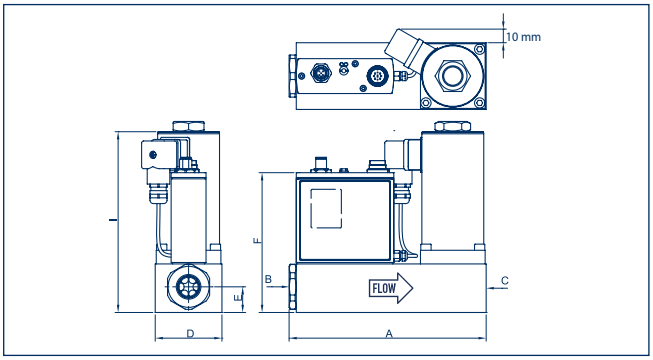
Dimensions for other models, please consult our website.
** ISO 1179-1 cavities*



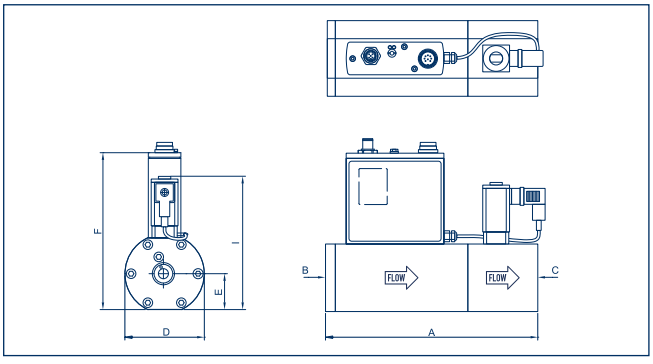
Model D-6410, D-6411, D-6420, D-6421, D-6440, D-6441, D-6460(A), D-6461/FAS



Model D-6470(A), D-6480, D-6490



Model D-6461(A)/002BI, D-6471/004BI



Model D-6471A/003AI, D-6481/003AI, D-6481/003BI, D-6491/003BI

Standard measurement ranges

Mass flow meter/controller Model				Flow ranges (Air) intermediate ranges are available
D-6410	Min.	0,01…0,2 l_n/min	Max.	0,1…2,0 l_n/min
D-6420	Min.	0,05…1,0 l_n/min	Max.	0,35…7,0 l_n/min
D-6440	Min.	0,14…7,0 l_n/min	Max.	0,5…50,0 l_n/min
D-6460	Min.	0,4…20,0 l_n/min	Max.	2,0…200 l_n/min
D-6460A	Min.	1,0…50,0 l_n/min	Max.	5,0…500 l_n/min
D-6470	Min.	2,0…100 l_n/min	Max.	10,0…1.000 l_n/min
D-6470A	Min.	4,0…200 l_n/min	Max.	20,0…2.000 l_n/min*
D-6480	Min.	10,0…500 l_n/min	Max.	50,0…5.000 l_n/min
D-6490	Min.	40,0…2.000 l_n/min	Max.	100…10.000 l_n/min
D-6411	Min.	0,01…0,2 l_n/min	Max.	0,1…2,0 l_n/min
D-6421	Min.	0,05…1,0 l_n/min	Max.	0,35…7,0 l_n/min
D-6441	Min.	0,14…7,0 l_n/min	Max.	1,0…50,0 l_n/min
D-6461/ D-6463	Min.	0,4…20,0 l_n/min	Max.	4,0…200 l_n/min
D-6461A	Min.	1,0…50,0 l_n/min	Max.	10,0…500 l_n/min
D-6471/ D-6473	Min.	2,0…100 l_n/min	Max.	20,0…1.000 l_n/min
D-6471A	Min.	4,0…200 l_n/min	Max.	20,0…2.000 l_n/min
D-6481/ D-6483	Min.	10,0…500 l_n/min	Max.	100…5.000 l_n/min
D-6491	Min.	40,0…2.000 l_n/min	Max.	200…10.000 l_n/min

** up to 2.500 l_n/min on request.*
Technical changes and alterations in construction are reserved.

On-board FLUIDAT®gas database

The on-board gas database contains the physical gas properties and is used for real-time corrections of the flow measurement based on the actual process temperature. As an optional feature, you may simply select your process gas, and benefit from the multi fluid, multi range possibilities of the D-6400 series. With the on-board gas database, it is very easy to switch to another gas or gas mixture without the need for recalibration.
MASS-STREAM™ mass flow meters and controllers are factory calibrated with Air as standard. In case other gases or gas mixtures are used, a conversion will be applied by means of the on-board gas database (FLUIDAT on board). The conversion depends on the physical properties of the gas and the process parameters, for instance the media temperature and operating pressure. The highly accurate FLUIDAT gas database ensures "best-in-class" conversion from Air to the customer gas.

When converting one gas to another, an additional small uncertainty is introduced. Although the gas properties and the conversion model are very accurate, the result can deviate slightly from the theoretical calculated values.

Flow profile and sensitivity

In general mass flow measurement is very sensitive to variations of the shape of the flow profile. The MASS-STREAM™ instruments are designed for a consistent, fully developed flow profile in the metering section. Installing a suitable well-sized inlet pipe is recommended for our robust and concurrent precise mass flow measurement. Without an inlet run or insufficient inlet piping conditions severe deviations in the accuracy could possibly occur.

Pressure loss

The pressure drop over the instrument's D-6400 measurement chamber is almost comparable to a straight run of pipe of the same diameter and is thus almost negligible.
However, to make the instruments less sensitive to upstream piping configurations (e.g. turbulences, welded joints, elbows) special mesh screens are required to condition the flow profile. These meshes create a certain pressure drop.
The frequently used compression fittings can cause a considerable additional pressure loss. We recommend to install fittings with maximized internal diameter. We would be happy to advise you on questions about the suitable inlet pipe in front of the instrument.

Enquiry and order information

In order to supply the correct instrument for your application, please submit the following data:

- Type of gas
- Flow range
- Operating temperature
- Operating pressure (for controllers inlet and back pressure)
- Electrical connection
- Type of fieldbus (if applicable)
- Type of fittings (only when needed)
- Analog or digital presettings

Mass Flow Controller model D-6471/004BI

Top Mount / Downported model (on request)

Technical specifications

Measurement system	
Accuracy (at calibration conditions)	± 1,0 % Rd plus ± 0,5 % FS
Repeatability	< ± 0,2 % FS
Pressure sensitivity	± 0,3 % Rd / bar typical (Air)
Temperature sensitivity	± 0,1 % Rd / °C (Air)
Attitude sensitivity	at 90° deviation from horizontal max. error 0,2 % at 1 bar typical N_2
Control stability	< 0,2 % FS typical
External leak integrity	< 2 x 10^{-8} mbar l/s He
Response time sensor (63 %)	D-641x / D-642x: approx. 0,3 seconds other models: approx. 0,9 seconds
Settling time (controller)	< 2 sec for direct acting valve < 5 sec for indirect acting valve
Certification	CE / RoHS

Mechanical parts	
Sensor	Stainless steel SS 316 (AISI 316)
Instrument body	Aluminium EN AW-6082-T6 or stainless steel SS 316
Sieves and rings	Stainless steel SS 316
Protection	IP65 (with and without display)
Process connections	Female gas thread (ISO1179-1)
Seals	standard: FKM/Viton®; options: EPDM, FFKM/Kalrez®, FDA and USP Class VI approved compounds

Operating limits	
Measuring range (turn-down-ratio)	up to 1…100 % (1:100) for meters up to 2…100 % (1:50) for controllers
Type of gases	almost all gases and gas-mixes, compatible with chosen materials
Temperature	0…50 °C
Storage / transport conditions	with display: 0…50 °C, max. 95% RH (non-condensing); without display: -20…+80 °C, max. 95% RH (non-condensing)
Pressure rating	0…10 bar (g) for instrument body in aluminium, 0…20 bar (g) for instruments body in stainless steel SS 316, 0…30 bar (g) on request
Warm-up time	30 minutes for optimum accuracy within 30 seconds for accuracy ± 4 % FS

Electrical properties	
Supply voltage	+15…24 Vdc ± 10 %
Current peak values	Meter approx. 75 mA at 0 % flow approx. 125 mA at 100 % flow Controller add 250 mA add 30 mA for display, if applicable add 50 mA for additional fieldbus, if applicable
Analog output	0…5 (10) Vdc or 0 (4)…20 mA (sourcing output)
Digital communication	standard: RS232 options: CANopen®, DeviceNet™, EtherCAT®, PROFIBUS DP, PROFINET, Modbus (RTU, ASCII or TCP/IP), EtherNet/IP, POWERLINK or FLOW-BUS

Electrical connection	
Analog, RS232	8 DIN (male);
PROFIBUS DP	bus: 5-pin M12 (female); power: 8 DIN (male)
Modbus TCP, EtherNet/IP, POWERLINK, EtherCAT®, PROFINET	bus: 2 x 4-pin M12 (female) (in/out); power: 8 DIN (male)
DeviceNet™, CANopen®	5-pin M12 (male)
Modbus-RTU/ASCII, FLOW-BUS	5-pin M12 (male)

Technical changes and alterations in construction are reserved.

Customized Input/Output configurations

Besides the I/O-options for measured and setpoint values via analog signals, RS232 or fieldbus communication, MASS-STREAM D-6400 instruments features a programmable pin (pin 5) at the 8DIN connector for customized Inlet/Outlet (I/O) configurations. This functionality can be used for advanced operations such as digital frequency/pulse output, alarm output/reset, processing an external setpoint signal, valve purge/close or analog valve output.

Bronkhorst FlowSuite

Bronkhorst FlowSuite is a software application for monitoring and service purposes on Bronkhorst instruments and gives a good insight into the dynamic behavior of Bronkhorst devices.

Bronkhorst FlowSuite allows you to:

- Configure controller, alarms, counters, totalizers
- Add or change the fluid settings of your device with FLUIDAT on board functionality
- Get insights, configure and visualize your personal dashboard or graphs

Bronkhorst FlowSuite can be downloaded from our website:
www.bronkhorst.com/FlowSuite

Mass Flow Meter model D-6470

Low-ΔP Mass Flow Controller model D-6471/DR3

Model number identification

D-64N	N	-	R	A	D	-	NN	-	V	-	A	-	D	-	D	A	-	000

Base model

D-641	up to 2 l_n/min
D-642	up to 7 l_n/min
D-644	up to 50 l_n/min
D-646	up to 200 l_n/min
D-646.A	up to 500 l_n/min
D-647	up to 1.000 l_n/min
D-647.A	up to 2.000 l_n/min*
D-648	up to 5.000 l_n/min
D-649	up to 10.000 l_n/min

** up to 2.500 l_n/min on request.*

Function

0	Meter
1	Controller with integrated valve
3	Controller with port connector and external valve

Communication and valve type

A	RS232 + analog	Normally closed
B	RS232 + analog	Normally opened
C	Powerlink	Normally closed
D	DeviceNet	Normally closed
E	DeviceNet	Normally opened
I	EtherNet/IP	Normally closed
J	EtherNet/IP	Normally opened
K	CANopen	Normally closed
L	CANopen	Normally opened
M	Modbus	Normally closed
N	Modbus	Normally opened
O	Powerlink	Normally opened
P	PROFIBUS DP	Normally closed
Q	PROFIBUS DP	Normally opened
R	FLOW-BUS	Normally closed
S	FLOW-BUS	Normally opened
T	EtherCAT	Normally closed
U	EtherCAT	Normally opened
V	PROFINET	Normally closed
W	PROFINET	Normally opened
X	Modbus-TCP	Normally closed
Y	Modbus-TCP	Normally opened

Analog output

A	0 - 5 Vdc
B	0 - 10 Vdc
F	0 - 20 mA sourcing
G	4 - 20 mA sourcing

Supply voltage

B	+24 Vdc
D	+15…24 Vdc

Gas connection inlet/outlet

00	None
11	⅛" OD compression type
22	¼" OD compression type
33	6 mm OD compression type
44	12 mm OD compression type
55	½" OD compression type
88	¼" Face seal male
DD	⅜" OD compression type
FF	1" OD compression type
GG	8 mm OD compression type
HH	10 mm OD compression type
LL	½" Face seal male
99	Other

Seals

V	FKM/Viton®
E	EPDM
K	FFKM/Kalrez®
B	EPDM USP/FDA
Z	Other

Body material

A	Aluminium EN AW-6082-T6
S	Stainless steel SS316

Display

0	None
D	with display

Controller mode

0	Controller disabled (meter only)
A	Analog control
D	Digital control

Integrated communication mode (pin 1/6) 8DIN

A	RS232 - (ProPar)
B	RS485 - FLOW-BUS
C	RS485 - Modbus RTU
D	RS485 - Modbus ASCII

Customized I/O options (pin 5) 8DIN**

000	Disabled, pin 5 is pulled down to 0 Vdc (default)
A1V	0…10 Vdc sourcing output, controller
B1V	4…20 mA sourcing output, controller
C3A	Digital output, min/max alarm
C4A	Digital output, counter alarm
C5S	Digital output, enabled by setpoint (for shut-off control)
C0I	Digital output, high/low switch via remote parameter
D9E	Digital frequency output, measure
F9B	Digital pulse output, batch counter
H1P	4…20 mA input, external pressure sensor
I3C	Digital input, controller mode valve close
I8C	Digital input, controller mode valve purge
I1R	Digital input, reset counter
I2R	Digital input, reset alarm

*** other on request.*

Bronkhorst®

Bronkhorst High-Tech designs and manufactures innovative instruments and subsystems for low-flow measurement and control for use in laboratories, machinery and industry. Driven by a strong sense of sustainability and with many years of experience, we offer an extensive range of (mass) flow meters and controllers for gases and liquids, based on thermal, Coriolis and ultrasonic measuring principles. Our global sales and service network provides local support in more than 40 countries. Discover Bronkhorst®!

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