BRONKHORST HI-TEC

SENSORS FOR MASS FLOW AND PRESSURE

LOW-ΔP-FLOW Mass Flow Meters/Controllers

FOR LOW PRESSURE DROP OR CORROSIVE GAS SERVICE

General

In a number of applications for measuring or controlling gas flows there is only little differential pressure available and/or allowable. These are the applications for which Bronkhorst High-Tech B.V. developed the LOW-ΔP-FLOW series, in which the flow resistance is minimised by using a large bore capillary in combination with a cylindrical type flow element. Based on this construction, air flow capacities up to 200 l_n/min can be measured. At a flow up to 1 l_n/min a pressure drop of less than 1 mbar is required.

The design and construction also result in a significantly longer lifetime even when used on corrosive gas service and lower contamination risk, combined with an easy-to-clean procedure.

All fluid wetted parts are of electro-polished stainless steel. The capillary and flow element can be supplied in Hastelloy and Monel on application. The instrument is helium leaktight. Standard seals are Viton, EPDM or PTFE, other materials are on request.

The Mass Flow Meters and Controllers of the LOW-ΔP-FLOW series have analog in- and output signals, 0...5(10) V or 0(4)...20 mA. In addition the instruments are available with a digital p.c. board with optional on-board interface to Profibus, DeviceNet, Modbus or FLOW-BUS.

As the LOW-ΔP-FLOW series instruments are often used in aggressive environments an IP65 classification housing is available (Type 'I'=Industrial).

The F-106Z and F-107Z series, which are also counted among the LOW-ΔP-FLOW have a different flow element and by-pass arrangement with low pressure drop.

LOW-ΔP-FLOW control

The control of mass flow with small pressure difference comprises the LOW-ΔP-FLOW Mass Flow Controller in compact construction (Models F-200DV/F-201D/F-202D/ F-201E/F-202E); control valve and flow meter are integrated in one body. The maximum flow in these compact models is 1…50 l_n/min Air, depending on the operating conditions.

For the control of higher flow rates at very low differential pressures Bronkhorst High-Tech B.V. has devised special control valves with pressure compensation bellows (types F-004AC/F-004BC). These control valves are piped on to the flow meter while the electronic PI-control function is an integral part of the flow meter. The F-004 series valves are described in a separate brochure.

We would recommend the expert advice of our specialist when dealing with difficult applications.

ISO 9001
ISO 14001

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SPECIFICATIONS AND FLOW RANGES

Technical specifications LOW-ΔP-FLOW

All fluid wetted parts of metal	: Stainless Steel, other on request
Seals	: Viton, EPDM, elast. PTFE, other on request
Electronic compartment	
Standard execution	: ABS, metallised
Industrial execution	: Aluminium, painted
Connections	
Series F-100/F-200	: ⅛" OD compression type
Series F-101/F-201	: ⅛", ¼" or 6 mm OD compression type (⅛" for max. 1 l_n/min Air)
Series F-102/F-202	: ¼", 6 mm, 12 mm or ½" OD compression type
Series F-103	: ½", 12 mm or 20 mm OD compression type; ¾" OD compression type on request
Series F-106Z	: mounting between flanges
Series F-107Z	: flanged connection

Electrical properties

Supply voltage for analog instruments	
Mass Flow Meter	: +15...24 V, 50 mA
MFC, standard execution	: +15 V, 250 mA -15 V, 30 mA
MFC, standard execution	: +15 or +24 V, 90 mA, add approx. 250 mA for control valve
MFC, industrial execution	: +15...24 V, 60 mA, add approx. 250 mA for control valve
Supply voltage for digital instruments	
Mass Flow Meter	: +15 or +24 V, 100 mA
Mass Flow Controller	: +15 or +24 V, 100 mA, add approx. 250 mA for control valve

Performance

Accuracy and linearity	: +/- 1% of full scale
Range	: 1 : 50
Repeatability	: < 0,2% of reading
Temperature coefficient	: < 0,1%/°C of full scale typical N_2
Pressure coefficient	: 0,1% / bar typical N_2
Operating temperature	: -10°C up to +70°C
Helium leak tightness	: 2 x 10^{-9} mbar.l.s^{-1} He
Output signal analog	: 0...5 (10) Vdc or 0 (4)...20 mA
digital	: standard: RS-232, option: Profibus-DP, DeviceNet, Modbus, FLOW-BUS
Mounting position	: horizontal
Response time	: 1...2 sec.
Maximum K_v-values	
F-200/F-201/F-202 (MFC)	: 6,6 x 10^{-2}
F-001AC (control valve)	: 6,6 x 10^{-2}
F-004AC (control valve)	: 3,0 x 10^{-1}
F-004BC (control valve)	: 1,0

Ranges (based on Air)

F-100D/F-200DV	: min. 0,2...10 ml_n/min;	max. 0,4...20 ml_n/min
F-101D/F-201D	: min. 0,3...15 ml_n/min;	max. 0,03...1,5 l_n/min
F-101DI	: min. 0,2...10 ml_n/min;	max. 0,03...1,5 l_n/min
F-101E/F-101EI/F-201E	: min. 0,03...1,5 l_n/min;	max. 0,2...10 l_n/min
F-102D/F-102DI/F202D	: min. 0,1...5 l_n/min;	max. 0,6...30 l_n/min
F-102E/F-102EI/F-202E	: min. 0,6...30 l_n/min;	max. 1...50 l_n/min
F-103D/F-103DI	: min. 0,4...20 l_n/min;	max. 2...100 l_n/min
F-103E/F-103EI	: min. 2...100 l_n/min;	max. 4...200 l_n/min
F-106Z/F-107Z	: min. 0,2...10 m^3_n/h;	max. 20...1000 m^3_n/h

Ranges and pressure drop Mass Flow Meters

Model	Flow ml_n/min Air	ΔP (mbar) at atm. ⅛" tube	¼" tube
F-100D/F-101DI	10	0,8	0,8
F-101D/F-101DI	20	0,8	0,8
F-101D/F-101DI	50	0,8	0,8
F-101D/F-101DI	100	0,8	0,8
F-101D/F-101DI	200	0,8	0,8
F-101D/F-101DI	500	0,8	0,8
F-101D/F-101DI	1000	0,8	0,8

Model	Flow l_n/min Air	ΔP (mbar) at atm. ¼" tube	½" tube
F-101E/F-101EI	2	5	5
F-101E/F-101EI	5	5,5	5
F-101E/F-101EI	10	6	5,5

Model	Flow l_n/min Air	ΔP (mbar) at atm. ¼" tube	½" tube
F-102D/F-102DI	5	1,5	0,8
F-102D/F-102DI	10	2	1
F-102D/F-102DI	20	5	2,5
F-102D/F-102DI	30	-	4

Model	Flow l_n/min Air	ΔP (mbar) at atm. ¼" tube	½" tube
F-102E/F-102EI	30	-	9
F-102E/F-102EI	50	-	15

Model	Flow l_n/min Air	ΔP (mbar) at atm. ½" tube	¾" tube
F-103D/F-103DI	20	0,8	0,8
F-103D/F-103DI	50	2	1,2
F-103D/F-103DI	100	5	3

Model	Flow l_n/min Air	ΔP (mbar) at atm. ½" tube	¾" tube
F-103E/F-103EI	100	-	8
F-103E/F-103EI	200	-	15

Model	Size DIN	ANSI	Flow m^3_n/h Air	ΔP (mbar) at atm.
F-106AZ/F-107AZ	DN40	1½"	10	7
F-106AZ/F-107AZ	DN40	1½"	20	13
F-106AZ/F-107AZ	DN40	1½"	50	35
F-106BZ/F-107BZ	DN50	2"	20	7
F-106BZ/F-107BZ	DN50	2"	50	18
F-106BZ/F-107BZ	DN50	2"	100	39
F-106CZ/F-107CZ	DN80	3"	50	7
F-106CZ/F-107CZ	DN80	3"	100	15
F-106CZ/F-107CZ	DN80	3"	200	32
F-106DZ/F-107DZ	DN100	4"	100	9
F-106DZ/F-107DZ	DN100	4"	200	17
F-106DZ/F-107DZ	DN100	4"	500	48
F-106EZ/F-107EZ	DN150	6"	200	7
F-106EZ/F-107EZ	DN150	6"	500	19
F-106EZ/F-107EZ	DN150	6"	1000	41

CONVERSION FACTORS AND APPLICATIONS

Conversion factors

To select the right model, we have to carry out two calculations:

1. Φ_{vn} Air = $\dfrac{\Phi_{vn} \text{ gas}}{\text{conversion factor}}$

2. Φ_{vn} Air = $\dfrac{\Phi_{vn} \text{ gas}}{\text{viscosity factor}}$

The highest flow rate calculated determines the flow capacity.

Example: Freon-22, 1 l_n/min
Conversion factor = 0,47
(see table below)
Viscosity factor = 0,31
(see table below)

1. Φ_{vn} Air = 1/0,47 = 2,13 l_n/min
2. Φ_{vn} Air = 1/0,31 = 3,23 l_n/min

Highest flow rate = 3,23 l_n/min, so we can select model F-201E, F-101E or F-101EI.

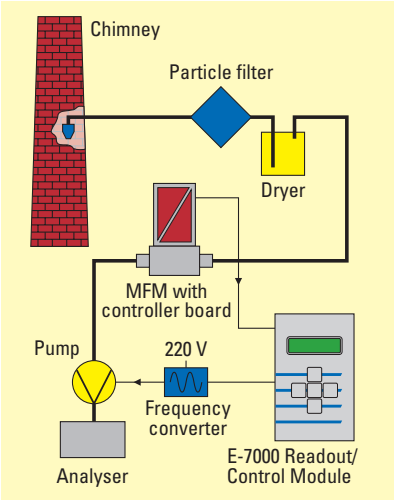
Applications

- Environmental air sampling at atmospheric conditions.
- Leak rate tests.
- Measurement of gas consumption, for example of natural gas, in low pressure gas distribution systems.
- Burner control.

Model F-106AZ LOW-ΔP-FLOW Mass Flow Meter

Example of application: Air sampling

An interesting example to control a flow rate is using a LOW-ΔP-FLOW Mass Flow Meters in combination with a sampling pump. In this configuration the speed of the pump is controlled to obtain the required mass flow rate, determined by the setpoint value.



Conversion factors and viscosity factors

Name	A	B	C
Acetylene (Ethyne)	C_2H_2	0,61	0,61
Air	Air	1,00	1,00
Allene (Propadiene)	C_3H_4	0,43	0,36
Ammonia	NH_3	0,77	0,86
Argon	Ar	1,40	1,08
Arsine	AsH_3	0,66	0,42
Boron trichloride	BCl_3	0,44	0,23
Boron trifluoride	BF_3	0,54	0,44
Bromine pentafluoride	BrF_5	0,26	0,20
Butadiene (1,3-)	C_4H_6	0,31	0,25
Butane	C_4H_{10}	0,25	0,21
Butene (1-)	C_4H_8	0,29	0,24
Butene (2-) (Cis)	C_4H_8	0,32	0,25
Butene (2-) (Trans)	C_4H_8	0,30	0,24
Carbonylfluoride	COF_2	0,54	0,46
Carbonylsulfide	COS	0,65	0,43
Carbon dioxide	CO_2	0,74	0,60
Carbon disulfide	CS_2	0,60	0,31
Carbon monoxide	CO	1,00	0,97
Chlorine	Cl_2	0,82	0,45
Chlorine trifluoride	ClF_3	0,40	0,29
Cyanogen	C_2N_2	0,48	0,35
Cyanogen chloride	ClCN	0,61	0,42
Cyclopropane	C_3H_6	0,43	0,36
Deuterium	D_2	1,00	2,14
Diborane	B_2H_6	0,43	0,43
Dibromo difluoromethane	Br_2CF_2	0,20	0,13
Dichlorosilane	SiH_2Cl_2	0,41	0,31
Dimethylamine	C_2H_6NH	0,37	0,31
Dimethylpropane (2,2-)	C_5H_{12}	0,21	0,18
Dimethylether	C_2H_6O	0,39	0,33
Disilane	Si_2H_6	0,31	0,35
Ethane	C_2H_6	0,49	0,49
Ethylene (Ethene)	C_2H_4	0,60	0,58
Ethylene oxide	C_2H_4O	0,52	0,41
Ethylacetylene (1-Butyne)	C_4H_6	0,32	0,26
Ethylchloride	C_2H_5Cl	0,41	0,29
Fluorine	F_2	0,91	0,96
Freon-11	CCl_3F	0,35	0,18
Freon-113	$C_2Cl_3F_3$	0,21	0,13
Freon-1132A	$C_2H_2F_2$	0,44	0,37
Freon-114	$C_2Cl_2F_4$	0,23	0,15
Freon-115	C_2ClF_5	0,24	0,17
Freon-116	C_2F_6	0,25	0,20
Freon-12	CCl_2F_2	0,37	0,22
Freon-13	$CClF_3$	0,40	0,28
Freon-13B1	$CBrF_3$	0,38	0,23
Freon-14	CF_4	0,44	0,37
Freon-21	$CHCl_2F$	0,44	0,25
Freon-22	$CHClF_2$	0,47	0,31
Freon-23	CHF_3	0,52	0,39
Freon-C318	C_4F_8	0,15	0,11
Helium	He	1,41	3,36
Helium (3-)	3He	1,44	3,91
Hydrogen	H_2	1,01	2,66
Hydrogen bromide	HBr	0,98	0,53
Hydrogen chloride	HCl	0,99	0,77
Hydrogen cyanide	HCN	0,75	0,53
Hydrogen fluoride	HF	0,96	0,95
Hydrogen iodide	HI	0,97	0,40
Hydrogen selenide	H_2Se	0,78	0,45
Hydrogen sulfide	H_2S	0,82	0,64
Isobutane	$C4H_{10}$	0,25	0,22
Isobutylene (Isobutene)	$C4H_8$	0,28	0,23
Krypton	Kr	1,43	0,75
Methane	CH_4	0,76	0,91
Methylacetylene	C_3H_4	0,43	0,36
Methylbromide	CH_3Br	0,61	0,33
Methylchloride	CH_3Cl	0,64	0,44
Methylfluoride	CH_3F	0,70	0,68
Methylmercaptan	CH_3SH	0,53	0,39
Mono-ethylamine	$C_2H_5NH_2$	0,36	0,30
Monomethylamine	CH_3NH_2	0,52	0,44
Neon	Ne	1,41	1,86
Nitric oxide	NO	0,97	0,98
Nitrogen	N_2	1,00	1,00
Nitrogen dioxide	NO_2	0,74	0,55
Nitrogen trifluoride	NF_3	0,50	0,43
Nitrosyl chloride	NOCl	0,61	0,38
Nitrous oxide	N_2O	0,71	0,59
Oxygen	O_2	0,98	1,00
Oxygen difluoride	OF_2	0,64	0,58
Ozone	O_3	0,70	0,56
Pentane	C_5H_{12}	0,21	0,18
Perchlorylfluoride	ClO_3F	0,41	0,29
Perfluoropropane	C_3F_8	0,16	0,13
Performa- ethylene	C_2F_4	0,33	0,26
Phosgene	$COCl_2$	0,47	0,27
Phosphine	PH_3	0,73	0,60
Propane	C_3H_8	0,34	0,31
Propylene (Propene)	C_3H_6	0,40	0,35
Silane	SiH_4	0,62	0,59
Sulfur dioxide	SO_2	0,68	0,43
Sulfur hexafluoride	SF_6	0,27	0,20
Trimethylamine	C_3H_9N	0,28	0,23
Tungsten hexafluoride	WF_6	0,25	0,14
Vinylchloride	C_2H_3Cl	0,47	0,33
Vinylfluoride	C_2H_3F	0,49	0,43
Xenon	Xe	1,38	0,54

A = symbol - **B** = conversion factor @ 20°C, 1 atm. - **C** = viscosity factor @ 20°C, 1 atm.

MODEL NUMBER IDENTIFICATION

F-NNNA – AAA – NN – A

Model	Ranges (based on Air)	
Mass Flow Meters (MFM), standard execution		
F-100D	min. 0,2...10 ml_n/min	max. 0,4...20 ml_n/min
F-101D	min. 0,3...15 ml_n/min	max. 30...1500 ml_n/min
F-101E	min. 0,03...1,5 l_n/min	max. 0,2...10 l_n/min
F-102D	min. 0,1...5 l_n/min	max. 0,6...30 l_n/min
F-102E	min. 0,6...30 l_n/min	max. 1...50 l_n/min
F-103D	min. 0,4...20 l_n/min	max. 2...100 l_n/min
F-103E	min. 2...100 l_n/min	max. 4...200 l_n/min
Mass Flow Meters (MFM), industrial execution (IP65)		
F-101DI	min. 0,2...10 ml_n/min	max. 30...1500 ml_n/min
F-101EI	min. 0,03...1,5 l_n/min	max. 0,2...10 l_n/min
F-102DI	min. 0,1...5 l_n/min	max. 0,6...30 l_n/min
F-102EI	min. 0,6...30 l_n/min	max. 1...50 l_n/min
F-103DI	min. 0,4...20 l_n/min	max. 2...100 l_n/min
F-106Z / F-107Z	min. 0,2...10 m^3_n/h	max. 20...1000 m^3_n/h
F-103EI	min. 2...100 l_n/min	max. 4...200 l_n/min
Mass Flow Controllers (MFC), standard execution		
F-200DV	min. 0,2...10 ml_n/min	max. 0,4...20 ml_n/min
F-201D	min. 0,3...15 ml_n/min	max. 30...1500 ml_n/min
F-201E	min. 0,03...1,5 l_n/min	max. 0,2...10 l_n/min
F-202D	min. 0,1...5 l_n/min	max. 0,6...30 l_n/min
F-202E	min. 0,6...30 l_n/min	max. 1...50 l_n/min
Typical combinations of MFM + Control Valve, standard execution		
F-102D + F-004AC	up to 0,6...30 l_n/min	K_v-max. 0,3
F-103D + F-004AC	up to 2...100 l_n/min	K_v-max. 0,3
Typical combinations of MFM + Control Valve, industrial execution (IP65)		
F-101DI + F-001AC	up to 0,1...1,5 l_n/min	K_v-max. 6,6 x 10^{-2}
F-102DI + F-004AC	up to 0,6...30 l_n/min	K_v-max. 0,3
F-103DI + F-004BC	up to 2...100 l_n/min	K_v-max. 1,0

Connections
(compression type couplings)

00	no couplings, female thread
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
66	20 mm OD compression type
88	1/4" Face Seal couplings
99	other

(mounting between flanges)

01	Mounting betw. flanges, DIN PN10
02	Mounting betw. flanges, DIN PN16
03	Mounting betw. flanges, DIN PN40
06	Mounting betw. flanges, ANSI 150
07	Mounting betw. flanges, ANSI 300
13	Flanged connection, DIN PN40
26	Flanged connection, ANSI 150
99	other

Seals

E	EPDM
P	Elast. PTFE
V	Viton
Z	other

P.C.Board (1st letter)

A	RS-232 + analog (nc)	M	RS-232 + Modbus (nc)
B	RS-232 + analog (no)	N	RS-232 + Modbus (no)
D	RS-232 + DeviceNet (nc)	P	RS-232 + Profibus (nc)
E	RS-232 + DeviceNet (no)	Q	RS-232 + Profibus (no)
F	Controller; analog (nc)	R	RS-232 + FLOW-BUS (nc)
G	Controller; analog (no)	S	RS-232 + FLOW-BUS (no)
H	Sensor; analog		

(nc) = normally closed controller function
(no) = normally opened controller function

Output signal (2nd letter)

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

Supply voltage (3rd letter)

A	+15 Vdc
B	+24 Vdc
C	+/-15 Vdc
D	+15...24 Vdc

Model F-101D
LOW-ΔP-FLOW
Mass Flow Meter

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