



EL-FLOW® Select

Digital Thermal Mass Flow Meters and Controllers for Gases



› Introduction

Bronkhorst High-Tech B.V., the European market leader in low flow thermal and Coriolis Mass Flow Meters/Controllers, has many years experience in designing and manufacturing precise and reliable measurement and control devices. With a wide range of instruments, Bronkhorst offers innovative solutions for many different applications in many different markets. The instruments are made to customers' specification, in various styles, suitable for use in laboratory, industrial and hazardous areas, in such diverse applications as semiconductor and analytical installations, to name but two.

› EL-FLOW® Select series

EL-FLOW® Select series Mass Flow Meters and Controllers for gas applications have a housing designed for laboratory and clean processing conditions. The instruments are truly unique in their capability to measure and control flow ranges between 0,014...0,7 mL/min and 8...1670 L/min with pressure rating between vacuum and 400 bar - all in one range of instruments. This versatility in flow ranges and in operating conditions has ensured that the EL-FLOW® Select series remains our most popular and field proven of instruments.

Today's EL-FLOW® Select series are equipped with a digital pc-board, offering high accuracy, excellent temperature stability and fast response (settling times τ_{98} down to 500 msec). The main digital pc-board contains all of the general functions needed for measurement and control. In addition to the standard RS232 output the instruments also offer analog I/O. Furthermore, an integrated interface board provides DeviceNet™, CANopen®, PROFIBUS®DP, Modbus, FLOW-BUS, EtherCAT®, PROFINET, Modbus/TCP or EtherNet/IP protocols.

› Selectable gases and flow ranges

The EL-FLOW® Select design features optional Multi-Gas / Multi Range functionality, providing (OEM-) customers with extra flexibility and process efficiency. Users of MFC's in pilot plants or laboratories can rescale their instruments on site, saving time and money; substantial costs for stock keeping, (dis)mounting and also for service and recalibration are no longer applicable. Our free and easy-to-use software tool 'FlowTune' enables the user to change the instrument's configuration swiftly via the RS232 port of a lap-top.

› Mass Flow Controllers for every application

The control valve can be furnished as integral part of an EL-FLOW® Select MFC, or as separate component. It is a proportional, electro-magnetic control valve with extremely fast and smooth control characteristics. With reference to the specific field of application there are different series of control valves. There is a standard direct acting valve for common applications, a pilot operated valve for high flow rates, the so-called Vary-P valve that can cope with 6 up to 400 bar ΔP and a bellows valve for applications with very low differential pressure.

› General EL-FLOW® Select features

- ◆ fast response, excellent repeatability
- ◆ high accuracy
- ◆ virtually pressure and temperature independent
- ◆ pressure ratings up to 400 bar
- ◆ optional metal sealed and downported constructions

› Digital features

- ◆ Fieldbus interfaces:
 - ◆ DeviceNet™, CANopen®
 - ◆ PROFIBUS DP, Modbus, FLOW-BUS
 - ◆ EtherCAT®, PROFINET, Modbus/TCP, EtherNet/IP
- ◆ optional Multi Gas / Multi Range functionality up to 10 bar
- ◆ storage of max. 8 calibration curves
- ◆ alarm and counter functions
- ◆ control characteristics user-configurable



F-203AV Mass Flow Controller for high flow applications



F-231M Mass Flow Controller for high pressure applications



F-112AC Mass Flow Meter

Technical specifications

Measurement / control system

Accuracy (incl. linearity) (based on actual calibration)	standard: $\pm 0,5\%$ Rd plus $\pm 0,1\%$ FS; $\pm 0,8\%$ Rd plus $\pm 0,2\%$ FS for F-110C-005/F-200CV-005; $\pm 2\%$ FS for F-110C-002/F-200CV-002
Turndown	up to 1:187,5 (1:50 in analog mode)
Repeatability	$< 0,2\%$ Rd
Settling time (controller)	standard: 1...2 seconds; option: down to 500 msec
Control stability	$< \pm 0,1\%$ FS (typical for 1 l _n /min N ₂)
Operating temperature	-10...+70°C
Temperature sensitivity	zero: $< 0,05\%$ FS/°C; span: $< 0,05\%$ Rd/°C
Pressure sensitivity	0,1% Rd/bar typical N ₂ ; 0,01% Rd/bar typical H ₂
Leak integrity, outboard	tested $< 2 \times 10^{-9}$ mbar l/s He
Attitude sensitivity	max. error at 90° off horizontal 0,2% at 1 bar, typical N ₂
Warm-up time	30 min. for optimum accuracy 2 min. for accuracy $\pm 2\%$ FS

Mechanical parts

Material (wetted parts)	stainless steel 316L or comparable
Process connections	compression type or face seal couplings
Seals	standard: Viton®; options: EPDM, Kalrez® (FFKM)
Ingress protection (housing)	IP40

Electrical properties

Power supply	+15...24 Vdc		
Max. power consumption	Supply	at voltage I/O	at current I/O
Meter	15 V	95 mA	125 mA
	24 V	65 mA	85 mA
Controller	15 V	290 mA	320 mA
	24 V	200 mA	215 mA
Extra for fieldbus (if applicable)			
Meter/Controller	15 V < 75 mA 24 V < 50 mA		
Analog output/command	0...5 (10) Vdc or 0 (4)...20 mA (sourcing output)		
Digital communication	standard: RS232 options: DeviceNet™, CANopen®, PROFIBUS®DP, Modbus RTU/ASCII, FLOW-BUS, EtherCAT®, PROFINET, Modbus/TCP, EtherNet/IP		

Electrical

Analog, RS232	9-pin D-connector (male)
PROFIBUS DP	bus: 9-pin D-connector (female) power: 9-pin D-connector (male)
DeviceNet™, CANopen®	5-pin M12-connector (male)
EtherCAT®, PROFINET, Modbus-TCP, EtherNet/IP	2 x RJ45 modular jack (in/out)
FLOW-BUS, Modbus-RTU/ASCII	RJ45 modular jack

Technical specifications and dimensions subject to change without notice.



F-111B Mass Flow Meter

Models and flow ranges (based on Air)

Mass Flow Meters (MFM); PN100 (pressure rating 100 bar)

Model	min. flow	max. flow
F-110C	0,014...0,7 ml _n /min	0,06...9 ml _n /min
F-111B	0,16...8 ml _n /min	0,16...25 l _n /min
F-111AC	0,4...20 l _n /min	0,6...100 l _n /min
F-112AC	0,8...40 l _n /min	1,4...250 l _n /min
F-113AC	4...200 l _n /min	8...1670 l _n /min

For ranges of 200 or 400 bar rated MFMs see model number identification.

Mass Flow Controllers (MFC); PN64 / PN100

Model	min. flow	max. flow
F-200CV/F-210CV ¹⁾	0,014...0,7 ml _n /min	0,06...9 ml _n /min
F-201CV/F-211CV ¹⁾	0,16...8 ml _n /min	0,16...25 ml _n /min
F-201AV/F-211AV ¹⁾	0,4...20 l _n /min	0,6...100 l _n /min
F-202AV/F-212AV ²⁾	0,8...40 l _n /min	1,4...250 l _n /min
F-203AV/F-213AV ³⁾	4...200 l _n /min	8...1670 l _n /min

¹⁾ K_{r-max} = $6,6 \times 10^{-2}$ ²⁾ K_{r-max} = 0,4 ³⁾ K_{r-max} = 1,5

Mass Flow Controllers (MFC); PN200

Model	min. flow	max. flow
F-220M ⁴⁾	0,2...10 ml _n /min	3...15 ml _n /min
F-221M ⁴⁾	0,3...15 ml _n /min	0,4...20 l _n /min

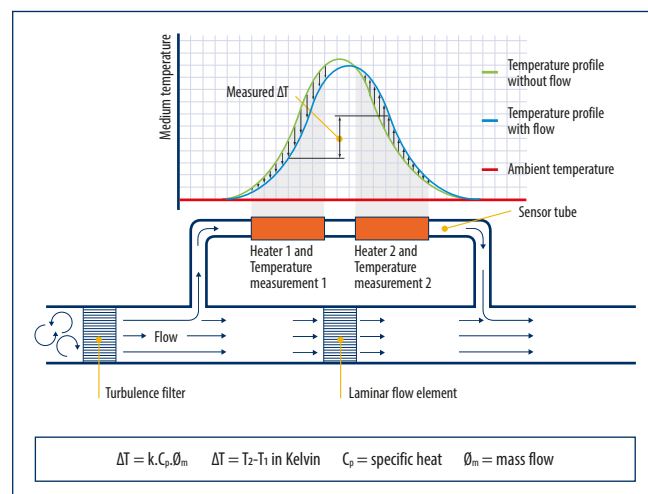
⁴⁾ K_{r-max} = $1,65 \times 10^{-3}$

MFCs for high-pressure / high-ΔP applications; PN400

Model	min. flow	max. flow
F-230M	0,2...10 ml _n /min	10...500 ml _n /min
F-231M	10...500 ml _n /min	0,2...10 l _n /min
F-232M	0,2...10 ml _n /min	2...100 l _n /min

Thermal mass flow measuring principle

The heart of the thermal mass flow meter/controller is the sensor, that consists of a stainless steel capillary tube with resistance thermometer elements. A part of the gas flows through this bypass sensor, and is warmed up by heating elements. Consequently the measured temperatures T₁ and T₂ drift apart. The temperature difference is directly proportional to mass flow through the sensor. In the main channel Bronkhorst applies a patented laminar flow element consisting of a stack of stainless steel discs with precision-etched flow channels. Thanks to the perfect flow-split the sensor output is proportional to the total mass flow rate.



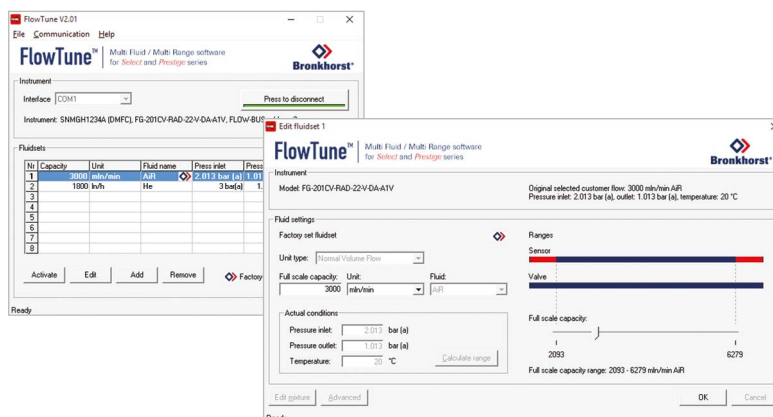
➤ **Table with minimum and maximum flow ranges for EL-FLOW®Select instruments suitable for Multi Fluid / Multi Range functionality** (valid for operating conditions from 0.8 to 10 bar abs and 0 to 70°C)

EL-FLOW Select MFM Model #	EL-FLOW Select MFC Model #	Air flow ranges	Min/Max flow ranges for other gases				
		Minimum/Nominal/Maximum	Ar	CH ₄	C ₂ H ₆	CO	
F-110C - 002	F-200CV - 002 ¹⁾	Min. 0,014 - 0,7 ml _n /min	Min.	0,02 - 1	0,012 - 0,6	0,008 - 0,4	0,014 - 0,7
		Nom. 0,014 - 2 ml _n /min	Max.	0,02 - 6	0,012 - 3,5	0,008 - 2	0,014 - 5
F-110C - 005	F-200CV - 005 ¹⁾	Min. 0,06 - 3 ml _n /min	Min.	0,07 - 3.5	0,04 - 2	0,028 - 1,4	0,06 - 3
		Nom. 0,06 - 5 ml _n /min	Max.	0,07 - 9.5	0,04 - 5,5	0,028 - 4	0,06 - 9
F-111B - 020	F-201CV - 020	Min. 0,16 - 8 ml _n /min	Min.	0,2 - 10	0,11 - 5,5	0,08 - 4	0,16 - 8
		Nom. 0,16 - 20 ml _n /min	Max.	0,2 - 30	0,11 - 18	0,08 - 13	0,16 - 30
F-111B - 050	F-201CV - 050	Min. 0,4 - 20 ml _n /min	Min.	0,54 - 27	0,34 - 17	0,22 - 11	0,4 - 20
		Nom. 0,4 - 50 ml _n /min	Max.	0,54 - 75	0,34 - 47	0,22 - 34	0,4 - 75
F-111B - 100	F-201CV - 100	Min. 0,8 - 40 ml _n /min	Min.	1,12 - 56	0,64 - 32	0,42 - 21	0,8 - 40
		Nom. 0,8 - 100 ml _n /min	Max.	1,12 - 150	0,64 - 95	0,42 - 70	0,8 - 150
F-111B - 200	F-201CV - 200	Min. 1,6 - 80 ml _n /min	Min.	2,4 - 120	1,3 - 65	0,88 - 44	1,6 - 80
		Nom. 1,6 - 200 ml _n /min	Max.	2,4 - 300	1,3 - 190	0,88 - 140	1,6 - 300
F-111B - 500	F-201CV - 500	Min. 4 - 200 ml _n /min	Min.	5,4 - 270	3,2 - 160	2,2 - 110	4 - 200
		Nom. 4 - 500 ml _n /min	Max.	5,4 - 750	3,2 - 470	2,2 - 340	4 - 750
F-111B - 1K0	F-201CV - 1K0	Min. 8 - 400 ml _n /min	Min.	11,2 - 560	6,4 - 320	4,2 - 210	8 - 400
		Nom. 8 - 1000 ml _n /min	Max.	11,2 - 1500	6,4 - 950	4,2 - 680	8 - 1500
F-111B - 2K0	F-201CV - 2K0	Min. 16 - 800 ml _n /min	Min.	24 - 1200	13 - 650	8,8 - 440	16 - 800
		Nom. 16 - 2000 ml _n /min	Max.	24 - 3000	13 - 1900	8,8 - 1300	16 - 3000
F-111B - 5K0	F-201CV - 5K0	Min. 0,04 - 2 l _n /min	Min.	0,054 - 2,7	0,032 - 1,6	0,022 - 1,1	0,04 - 2
		Nom. 0,04 - 5 l _n /min	Max.	0,054 - 7,5	0,032 - 4,7	0,022 - 3,3	0,04 - 7,5
F-111B - 10K	F-201CV - 10K	Min. 0,08 - 4 l _n /min	Min.	0,112 - 5,6	0,064 - 3,2	0,042 - 2,1	0,08 - 4
		Nom. 0,08 - 10 l _n /min	Max.	0,112 - 15	0,064 - 9,5	0,042 - 6,9	0,08 - 15
F-111B - 20K	F-201CV - 20K	Min. 0,16 - 8 l _n /min	Min.	0,2 - 10	0,13 - 6,5	0,088 - 4,4	0,16 - 8
		Nom. 0,16 - 20 l _n /min	Max.	0,2 - 25	0,13 - 16	0,088 - 11	0,16 - 25
F-111AC - 50K	F-201AV - 50K	Min. 0,4 - 20 l _n /min	Min.	0,54 - 27	0,32 - 16	0,22 - 11	0,4 - 20
		Nom. 0,4 - 50 l _n /min	Max.	0,54 - 75	0,32 - 47	0,22 - 34	0,4 - 75
F-111AC - 70K	F-201AV - 70K	Min. 0,6 - 30 l _n /min	Min.	0,9 - 45	0,5 - 25	0,4 - 20	0,6 - 30
		Nom. 0,6 - 70 l _n /min	Max.	0,9 - 100	0,5 - 60	0,4 - 45	0,6 - 100
F-112AC - M10	F-202AV - M10 ¹⁾	Min. 0,8 - 40 l _n /min	Min.	1,12 - 56	0,64 - 32	0,42 - 21	0,8 - 40
		Nom. 0,8 - 100 l _n /min	Max.	1,12 - 150	0,64 - 95	0,42 - 68	0,8 - 150
F-112AC - M20	F-202AV - M20 ¹⁾	Min. 1,4 - 70 l _n /min	Min.	2 - 100	1,1 - 55	0,7 - 35	1,4 - 70
		Nom. 1,4 - 200 l _n /min	Max.	2 - 250	1,1 - 170	0,7 - 120	1,4 - 250
F-113AC - M50	F-203AV - M50 ¹⁾	Min. 4 - 200 l _n /min	Min.	5,4 - 270	3,2 - 160	2,2 - 110	4 - 200
		Nom. 4 - 500 l _n /min	Max.	5,4 - 750	3,2 - 470	2,2 - 340	4 - 750
F-113AC - 1M0	F-203AV - 1M0 ¹⁾	Min. 8 - 400 l _n /min	Min.	11,2 - 560	6,4 - 320	4,2 - 210	8 - 400
		Nom. 8 - 1000 l _n /min	Max.	11,2 - 1670	6,4 - 900	4,2 - 750	8 - 1500
		Max. 8 - 1670 l _n /min					

¹⁾ Multi Gas / Multi Range option not available for these models

➤ **Multi Gas / Multi Range features**

- ◆ Rangeability up to 187,5 : 1
- ◆ Flexible, user-programmable ranges and gas types
- ◆ Easy-to-use configuration software
- ◆ Multi Gas / Multi Range functionality up to 10 bar; pressure rating up to 100 bar
- ◆ High accuracy and repeatability

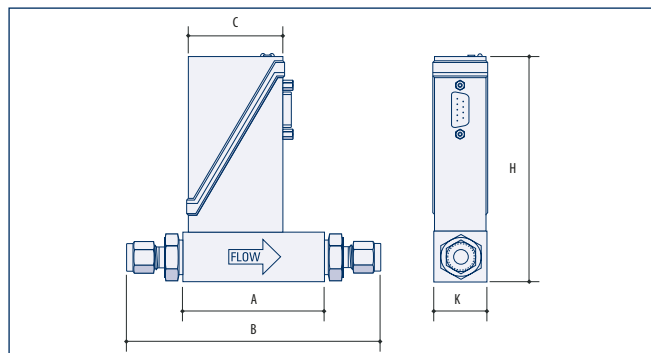


CO ₂	H ₂	He	N ₂	N ₂ O	O ₂	
0,012 - 0,6	0,014 - 0,7	0,02 - 1	0,014 - 0,7	0,012 - 0,6	0,014 - 0,7	ml _r /min
0,012 - 3	0,014 - 5	0,02 - 7	0,014 - 5	0,012 - 3	0,014 - 5	
0,04 - 2	0,06 - 3	0,07 - 3,5	0,06 - 3	0,04 - 2	0,06 - 3	
0,04 - 4,5	0,06 - 7,2	0,07 - 10	0,06 - 9	0,04 - 4,5	0,06 - 9	
0,14 - 7	0,144 - 7,2	0,2 - 10	0,16 - 8	0,12 - 6	0,16 - 8	
0,14 - 16	0,144 - 25	0,2 - 35	0,16 - 30	0,12 - 16	0,16 - 30	
0,3 - 15	0,42 - 21	0,56 - 28	0,4 - 20	0,3 - 15	0,4 - 20	
0,3 - 39	0,42 - 65	0,56 - 90	0,4 - 75	0,3 - 38	0,4 - 73	
0,62 - 31	0,84 - 42	1,12 - 56	0,8 - 40	0,6 - 30	0,8 - 40	
0,62 - 79	0,84 - 130	1,12 - 180	0,8 - 150	0,6 - 77	0,8 - 140	
1,22 - 61	1,68 - 84	2,4 - 120	1,6 - 80	1,2 - 60	1,6 - 80	
1,22 - 150	1,68 - 260	2,4 - 360	1,6 - 300	1,2 - 150	1,6 - 290	
3 - 150	4,2 - 210	5,6 - 280	4 - 200	3 - 150	4 - 200	
3 - 390	4,2 - 650	5,6 - 900	4 - 750	3 - 380	4 - 730	
6,2 - 310	8,4 - 420	11,2 - 560	8 - 400	6 - 300	8 - 400	
6,2 - 790	8,4 - 1300	11,2 - 1800	8 - 1500	6 - 770	8 - 1400	
12,2 - 610	16,8 - 840	24 - 1200	16 - 800	12 - 600	16 - 800	l _m /min
12,2 - 1500	16,8 - 2600	24 - 3600	16 - 3000	12 - 1500	16 - 2900	
0,03 - 1,5	0,042 - 2,1	0,056 - 2,8	0,04 - 2	0,03 - 1,5	0,04 - 2	
0,03 - 3,9	0,042 - 6,5	0,056 - 9	0,04 - 7,5	0,03 - 3,8	0,04 - 7,3	
0,062 - 3,1	0,084 - 4,2	0,112 - 5,6	0,08 - 4	0,06 - 3	0,08 - 4	
0,062 - 7,9	0,084 - 13	0,112 - 18	0,08 - 15	0,06 - 7,7	0,08 - 14	
0,122 - 6,1	0,168 - 8,4	0,24 - 12	0,16 - 8	0,12 - 6	0,16 - 8	
0,122 - 14	0,168 - 25	0,24 - 30	0,16 - 25	0,12 - 14	0,16 - 25	
0,3 - 15	0,42 - 21	0,56 - 28	0,4 - 20	0,3 - 15	0,4 - 20	
0,3 - 39	0,42 - 65	0,56 - 90	0,4 - 75	0,3 - 38	0,4 - 73	
0,5 - 25	0,6 - 30	0,9 - 45	0,6 - 30	0,5 - 25	0,6 - 30	
0,5 - 50	0,6 - 90	0,9 - 125	0,6 - 100	0,5 - 50	0,6 - 90	
0,62 - 31	0,84 - 42	1,12 - 56	0,8 - 40	0,6 - 30	0,8 - 40	
0,62 - 79	0,84 - 130	1,12 - 180	0,8 - 150	0,6 - 77	0,8 - 140	
1 - 50	1,4 - 70	2 - 100	1,4 - 70	1 - 50	1,4 - 70	
1 - 130	1,4 - 200	2 - 300	1,4 - 250	1 - 130	1,4 - 250	
3 - 150	4,2 - 210	5,6 - 280	4 - 200	3 - 150	4 - 200	
3 - 390	4,2 - 650	5,6 - 900	4 - 750	3 - 380	4 - 730	
6,2 - 310	8,4 - 420	11,2 - 560	8 - 400	6 - 300	8 - 400	
6,2 - 850	8,4 - 1350	11,2 - 1850	8 - 1670	6 - 840	8 - 1500	

Notes

- Multi Gas / Multi Range is optional on the Select series and must be requested at the point of ordering
- Extended rangeability for digital communication only; turndown 50:1 when using analog I/O options
- The selected orifice of the control valve may limit the rangeability
- Standard accuracy (based on actual calibration): $\pm(0,5\% \text{ RD} + 0,1\% \text{ FS})$;
 $\pm 0,8\% \text{ Rd}$ plus $\pm 0,2\% \text{ FS}$ for F-110C-005/F-200CV-005; $\pm 2\% \text{ FS}$ for F-110C-002/F-200CV-002
- Maximum range for gases not mentioned in this list; rule of thumb: nominal range for Air x Conversion Factor;
e.g. F-111B - 1K0: maximum range for SF₆ = 1000 x 0.27 = 270 ml_r/min
- Minimum range for gases not mentioned in this list; rule of thumb: minimum range for Air x Conversion Factor;
e.g. F-111B - 1K0: minimum range for SF₆ = 400 x 0.27 = 108 ml_r/min
- The Conversion Factors for these calculations can be extracted from Fluidat on the Net (www.fluidat.com): Go to 'Flow calculations' and select 'Gas Conversion factor'. Select 'Fluid from' and make sure 'Fluid to' is Air. Select the applicable instrument model from the pulldown menu. Then press 'Calculate' and look up the conversion factor from the table.

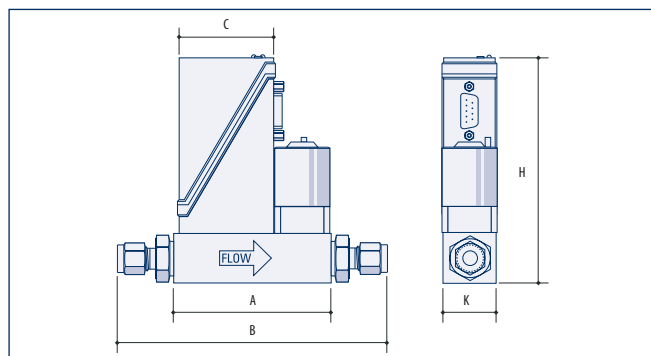
› Dimensions



Mass Flow Meter

Model	A	B	C	H	K	Weight (kg)
F-110C (1/8" OD)	47	98	47	111	25	0,4
F-111B (1/4" OD)	69	126	47	111	25	0,5
F-111AC (1/4" OD)	69	126	47	123	26	0,6
F-112AC (1/2" OD)	65	130	47	139	59	1,3
F-113AC (1/2" OD)	112	179	47	153	74	3,0

Dimensions in mm.



Mass Flow Controller

Model	A	B	C	H	K	Weight (kg)
F-200CV/F-210CV (1/8" OD)	77	128	47	111	25	0,6
F-201CV/F-211CV (1/4" OD)	77	134	47	111	25	0,6
F-201AV/F-211CV (1/4" OD)	78	135	47	123	26	0,7
F-202AV/F-212AV (1/2" OD)	112	169	47	139	59	2,1
F-203AV/F-213AV (1/2" OD)	171	238	47	153	74	4,9
F-220M/F-221M (1/4" OD)	85	139	47	126	28	0,9
F-230M/F-231M/F-232M (1/4" OD)	115	172	47	163	69	3,4

Dimensions in mm.

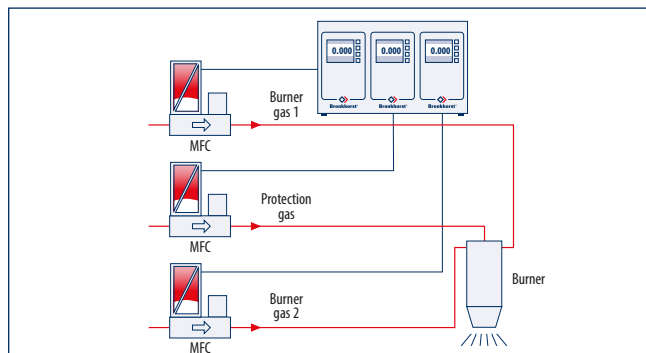
› Fields of application

The EL-FLOW® Select series have been successfully applied in a wide variety of both OEM and laboratory applications in the following markets (typically):

- ◆ Semiconductor processing
- ◆ Analysis and environmental measurements
- ◆ Burner control
- ◆ Vacuum technology
- ◆ Surface treatment installations
- ◆ Process control in food, pharmaceutical and (petro-) chemical industries

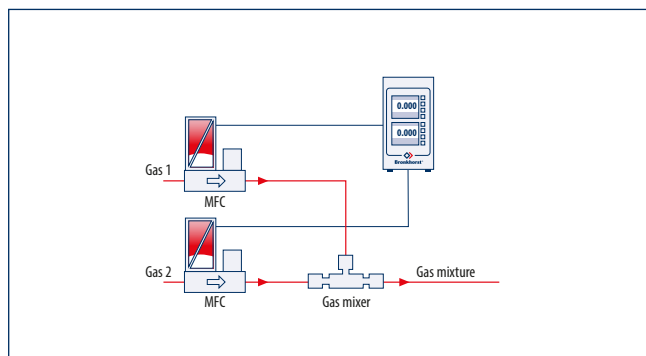
To give an impression of the many varied applications, we hereby sketch some basic examples. In reality, these applications are commonly far more complex and with far more variations and adaptations.

› Burner control



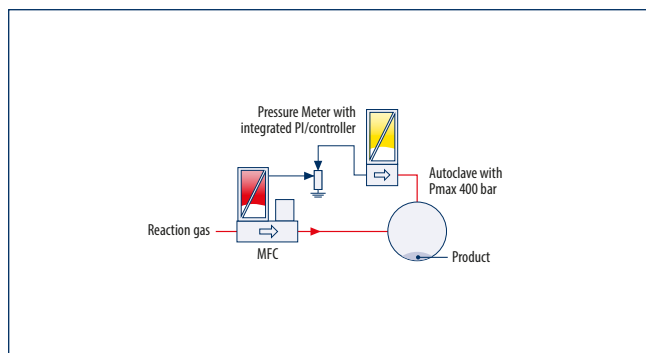
Burner control using Mass Flow Controllers brings many advantages compared to conventional systems, where flow is adjusted through needle valves. When burner orifices get clogged or when gas supply pressure varies, an MFC will automatically adapt to the changed conditions. For the control of relatively large flows with low differential pressure, which is typical for natural gas or CH₄, Bronkhorst offers mass flow meters with separate pressure compensated bellows valves.

› Making gas mixtures



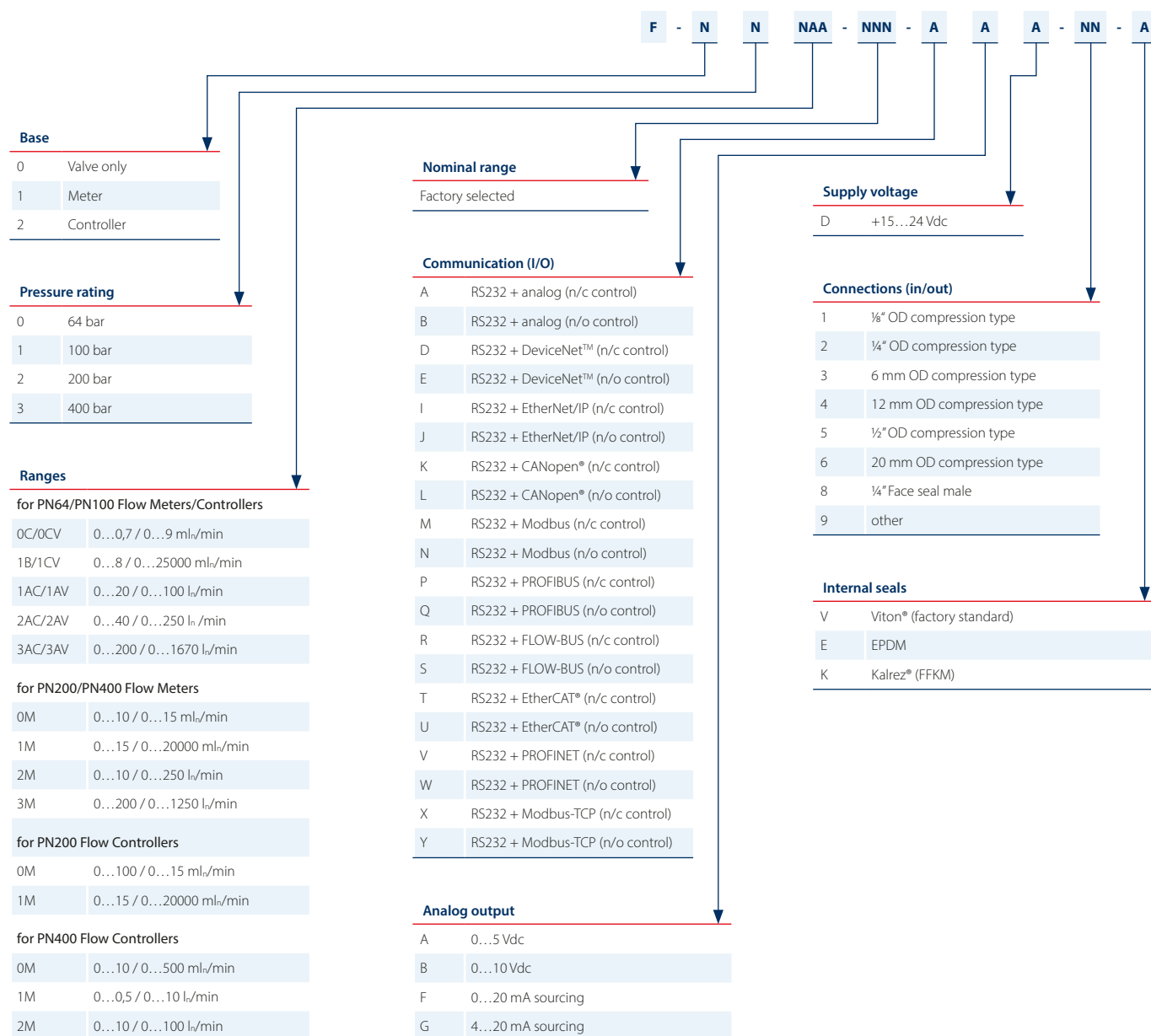
MFC's are often used to make precise and stable mixtures of two or more gases. A Bronkhorst® PS/Readout system can be applied to maintain the ratio of mixed gases by operating in master-slave mode. In the example above, the flow range of gas 1 is much smaller than the other. For this purpose Bronkhorst developed a gas mixer, to guarantee a homogeneous gas mixture.

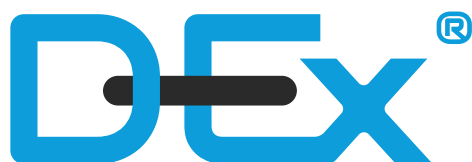
› Feeding of reactors



Flow control is often combined with the control of reactor pressure, using an EL-PRESS back pressure controller, or as depicted, an EL-PRESS Pressure Meter with integrated PI-controller. Typical applications: high pressure hydrogenation systems and autoclave processes using a 400 bar rated Mass Flow Controller with Vary-P control valve.

Model number identification





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