

EL-FLOW®

THERMAL MASS FLOW METERS AND CONTROLLERS FOR GASES



FLOW CAPACITIES (AIR):

MIN. 0-1 ml_n/min; MAX. 0-1250 l_n/min

PRESSURE RATINGS UP TO 400 BAR

ACCURATE 3F CALIBRATION

NO MOVING PARTS

FAST TIME RESPONSE

MODULAR CONCEPT

BRONKHORST
HI-TEC

INTRODUCTION AND CONTENTS

INTRODUCTION

This brochure describes the instruments of the EL-FLOW series. These thermal Mass Flow Meters and Controllers are of modular construction with "laboratory style" pc-board housing. Furthermore it includes a brief description of the LOW- Δ P-FLOW and the COMBI-FLOW series, both related to the EL-FLOW series, but designed for special conditions. For Bronkhorst Hi-Tec products for other applications please refer to page 23 or our general brochure.

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GOING DIGITAL

Increasing numbers of customers now prefer our digital mass flow meters/controllers over the standard analog instruments and no wonder! Bronkhorst High-Tech's digital instruments offer polynomial calibration accuracy as standard, have additional functions such as totalisation and alarms, and can easily be hooked-up to a number of fieldbus systems by simply adding an on-board interface. Last but not least, going digital is an easy commercial decision, as the enhanced digital options are extremely cost effective. Read more about digital instruments on page 13 of this brochure or ask our local representatives for the "Multi-Bus" leaflet.

BRONKHORST HIGH-TECH BV

PRODUCT RANGE

Bronkhorst High-Tech B.V. was established in 1981 and now offers a very wide range of thermal and coriolis mass flow meters and controllers. Numerous styles of both standard and customized instruments can be offered for applications in laboratory, industrial and hazardous areas. The full scale measuring range (with 50:1 turn-down) for these instruments can be selected between 0...1 ml_n/min and 0...10000 m³_n/h for gases and 0...30 mg/h up to 0...600 kg/h for liquids.

Furthermore Bronkhorst High-Tech offers pressure transducers and controllers with a minimum range of 0...100 mbar and a maximum range of 0...400 bar.

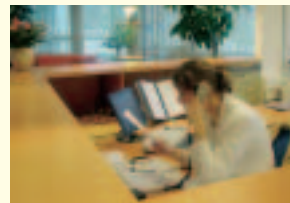


ROUND-THE-CLOCK SUPPORT

Bronkhorst High-Tech is a truly worldwide organisation with its Head Office being located in the town of Ruurlo in The Netherlands. With a total head-count now exceeding 220 employees, it is impressive that 45 of these are involved with R&D, 100 in manufacture and 40 involved with after-sales service and customer care. In actual fact, the Customer Service Department offers "round-the-clock" support, seven days a week, to customers in every corner of the world.

SALES REPRESENTATION AND SERVICE

In addition to the sales office in Veenendaal of The Netherlands there are branch offices in Great Britain, France, Switzerland and northern Germany whereby local expertise and service is offered. Bronkhorst High-Tech has also built up an extensive complimentary network of distributors and service stations across the rest of Europe and, indeed, yet further representation in such countries as the USA, China, Japan, Australia, New Zealand, Canada, Israel, India, South Africa, Brazil and Korea.

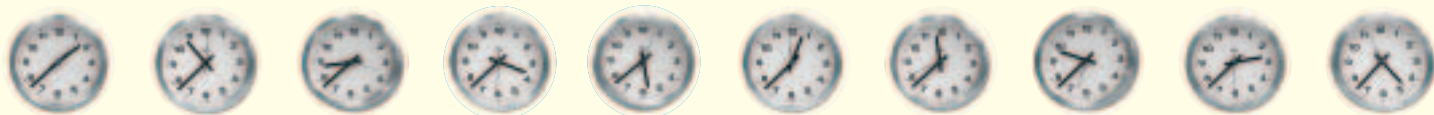


QUALITY

Customer satisfaction, innovation and quality of product and service have been the cornerstones of Bronkhorst High-Tech's success. In 1987 the company obtained the Koning Willem I Award for a young successful enterprise and in 1992 the company was accredited to ISO 9001 with ISO 14001 (an International Standard for environmental management) following three years later.



In January 2004 this ongoing commitment was rewarded by accreditation to the most recent Quality Management System, ISO 9001:2000.



INTRODUCTION

WHAT IS MASS? WHAT IS l_n OR ml_n ?

Imagine you have a cylinder of 1 litre, which is closed by means of a moveable piston of negligible weight. This cylinder contains 1 litre of air at ambient pressure, approx. 1 bar. The weight of this volume of air at 0 °C is 1.293 g, this is the mass. When we move the piston half way to the bottom of the cylinder, then the contained volume of air is only ½ litre, the pressure is approx. 2 bar, *but the mass is unchanged*, 1.293 g; nothing has been added, or left out.

Following this example, mass flow should actually be expressed in units of weight such as g/h, mg/s, etc. Most users, however, think and work in units of volume. No problem, provided conditions are agreed upon, under which the mass is converted to volume. A temperature of 0 °C and a pressure of 1,013 bar are selected, and these reference conditions are indicated by the underlying letter “n” in the unit of volume used.

The direct thermal mass flow measurement method is always based on these reference conditions unless otherwise requested. There are cases, for instance, where the reference conditions are based on 20 °C instead of 0 °C. If this difference is not considered, then there is an error of 7%!

MASS FLOW MEASUREMENT IS MORE ACCURATE

With other principles of measurement velocity, volume or differential pressure are measured. With these principles it is necessary to correct 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. In addition to this comes the high turndown of 1:50.

BRONKHORST HI-TEC MASS FLOW METERS AND CONTROLLERS ARE ESPECIALLY ACCURATE

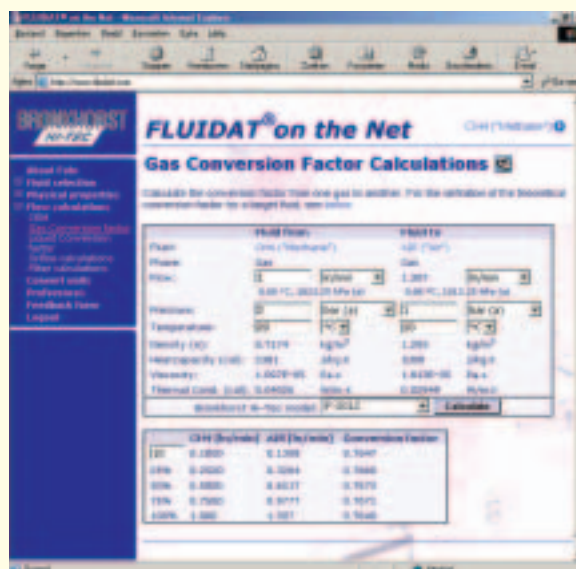
Based on some patented parts and special calibration procedures the analog instruments achieve accuracies and repeatabilities that other makes can only achieve with digital techniques (see pages 9 and 16). Just talk to your distributor about the required accuracy for your particular application.

THE ROLE OF THE CONTROL VALVE SHOULD NOT BE UNDERESTIMATED

Only Bronkhorst High-Tech B.V. offers different model ranges, not just suitable up to pressures of 700 bar, but also capable of coping with high and extremely low differential pressures, and with high flow rates. Thanks to a modular construction the control valves can be field adjusted to changing operating conditions (see pages 10 and 11).

CONVERSION FACTORS ARE OUT OF DATE

For the first time in this brochure we do not publish a conversion factor list. Instead the Hi-Tec users profit by the much more accurate conversion factors that are individually determined by means of the FLUIDAT-program (see page 17). Those who often change to gases of a different kind or where the gas composition changes should use this software. Get your free registration at www.fluidat.com.



YOU HAVE THE CHOICE

whether you only buy the compact instrument (for instance as an OEM), or the complete system (see pages 18/20). Your distributor will advise you.

Further to this introductory information we also suggest you read chapter “The special Bronkhorst High-Tech achievements” on pages 16/17.

THE PRINCIPLE OF OPERATION OF THERMAL MASS FLOW MEASUREMENT AND CONTROL FOR GASES

To measure mass flow, various methods can be applied, but below we outline the *thermal measuring principle*, as it is used by Bronkhorst High-Tech B.V.

The user need not necessarily know these details to successfully apply Hi-Tec instruments, but it helps to understand things better with regard to time- and control characteristics of the instruments.

PRINCIPLE OF OPERATION

As shown in figure A a part of the gas flows through the Sensor, and is warmed up by heater R_H . Consequently the measured temperatures T_1 and T_2 drift apart, as shown in figure B. The formulas for ΔT demonstrate that the temperature difference is directly proportional to mass flow.

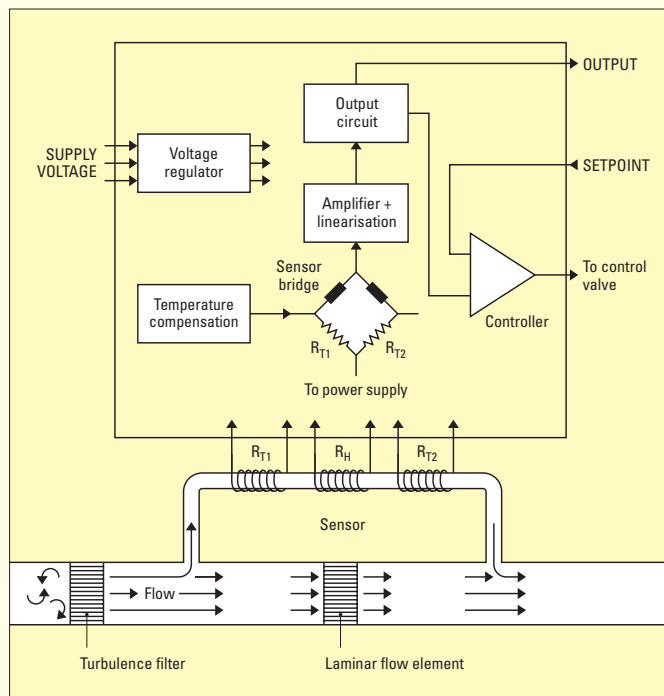


FIGURE A

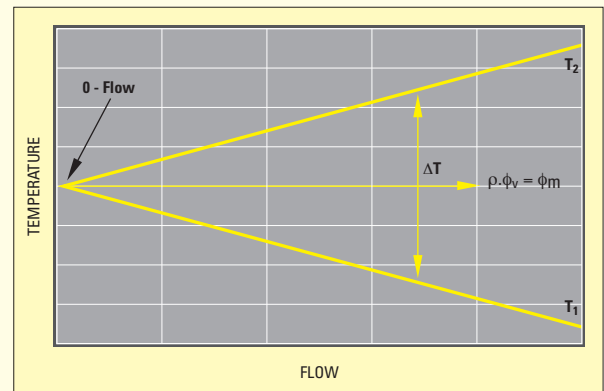


FIGURE B

$$\Delta T = k \cdot C_p \cdot \rho \cdot \phi_v$$

or

$$\Delta T = k \cdot C_p \cdot \phi_m$$

$$\Delta T = T_2 - T_1 \text{ in Kelvin}$$

$$C_p = \text{specific heat}$$

$$\rho = \text{density}$$

$$\phi_v = \text{volume flow}$$

$$\phi_m = \text{mass flow}$$

Electrically, temperatures T_1 and T_2 are in fact temperature dependent resistors R_{T1} and R_{T2} . In figure A it is shown how the signals measured in the sensor are amplified to electric signals. All common output signals are available and one can be selected.

In the case of mass flow control, the output signal is continuously compared with a setpoint signal from a voltage source. Any deviations between setpoint signal and measured signal are translated into a control valve adjustment until the two signals are identical.

This is only a basic explanation of the principle, as it is applied by Bronkhorst High-Tech, but be confident that more than 300.000 instruments in the field prove it to be reliable. More details are given in chapter "The special Bronkhorst High-Tech achievements" (page 16 and 17).

EL-FLOW[®] MASS FLOW METERS FOR GASES

GENERAL

Instruments of the EL-FLOW series are mass flow meters and controllers in modular construction with an electronics housing suitable for common laboratory type and non-weatherproof industrial type ambient conditions. In order to convert a mass flow meter to a controller, a control valve is used; normally the control valve would be integrated (see next page), but it can also be mounted separately.

FEATURES OF THE EL-FLOW MASS FLOW METERS

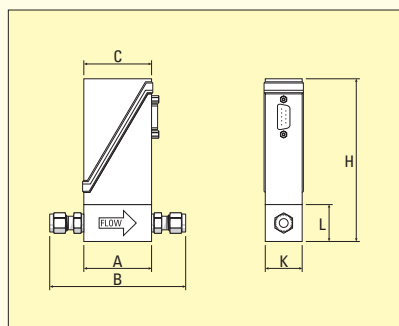
- No moving parts.
- All metal surfaces electro-chemically polished.
- Fast response time.
- Flow computer not needed.
- Temperature measurement not needed.
- Pressure measurement not needed.
- Low pressure drop.
- Operating pressures up to 400 bar (higher on application).
- Virtually attitude insensitive.

These series comprise gas flows between the smallest range of 0,02...1 ml_n/min and the highest range of 25...1250 l_n/min.

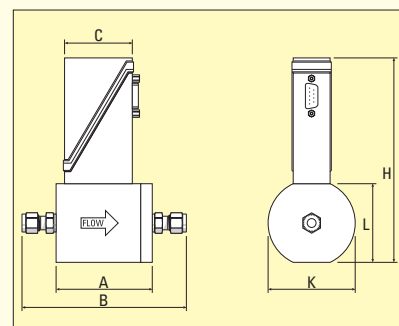
The pressure drop is approx. 35 mbar at maximum flow for the F-110C/ F-111C series and approx. 70 mbar for the F-112AC/F-113AC series. In applications where this is too high, the LOW-ΔP-FLOW series must be used (see page 14).

FIELDS OF APPLICATION

- Analysis and environmental measurements.
- Gas flow control in the food, chemical, petrochemical and pharmaceutical industries.
- Gas flow consumption measurement for internal accounting purposes.
- Measurement of gas flow development in batteries.
- Permeability measurement in filters and membranes.
- Flow measurement in orifices.
- Measurement of H₂ flow in hydrogenation processes.
- Leak rate tests.



EL-FLOW F-111C



Model	Dimensions (mm)					Weight	
	A	B	C	H	K	L	(kg)
F-110C/F-111C	47	97	46	111	25	25	0,4

Dimensions and weights of other models are available on request.

Model	Dimensions (mm)					Weight	
	A	B	C	H	K	L	(kg)
F-112AC	65	115	47	139	59	53	1,3
F-113AC	112	181	47	153	74	67	3,0

FLOW RANGES (BASED ON AIR, INTERMEDIATE RANGES ARE AVAILABLE)

smallest range	highest range	Pressure rating / model		
		100 bar	200 bar	400 bar
0,02 .....1 ml _n /min	0,2 .....10 ml _n /min	F-110C		
0,2 .....10 ml _n /min	0,3 .....15 ml _n /min	F-111C	F-120M	F-130M
0,3 .....15 ml _n /min	0,3.....15 l _n /min	F-111C	F-121M	F-131M
0,2.....10 l _n /min	5.....250 l _n /min	F-112AC	F-122M	F-132M
2.....100 l _n /min	25.....1250 l _n /min	F-113AC	F-123M	F-133M

EL-FLOW[®] MASS FLOW CONTROLLERS FOR GASES

GENERAL

EL-FLOW mass flow controllers are the only MFCs on the market that can handle flow ranges between 0...1 ml_n/min and 0...1250 l_n/min and operating pressures between vacuum and 400 bar in one single series of instruments. The models of this series are identified on page 8. All instruments of a particular model have identical dimensions.



EL-FLOW F-201C

Bronkhorst Hi-Tec instruments of the EL-FLOW series offer in particular:

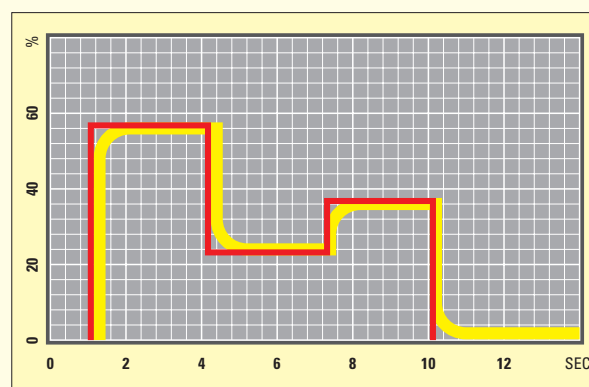
- accuracy.
- stability.
- serviceability.
- quality.

This is achieved thanks to the use of the latest technologies both mechanical and electronic:

- modular construction.
- electro-chemical polishing.
- SMT components.
- noise signal suppression.
- automatic temperature compensation.
- internal voltage regulation.

The control valve design distinguishes itself from competitive designs in its truly modular construction and it can be field replaced or changed by the user without any adjustment. The standard valve is normally closed and is available up to K_v -values of 1.5. Normally opened valves can also be supplied. Patented constructions enable us to handle high flows and/or pressures at differential pressures up to 400 bar in the EL-FLOW programme, which is unique.

FAST RESPONSE



Fast response control without over/undershoot, even with large setpoint step changes, ensures that the output signal corresponds with the actual flow.

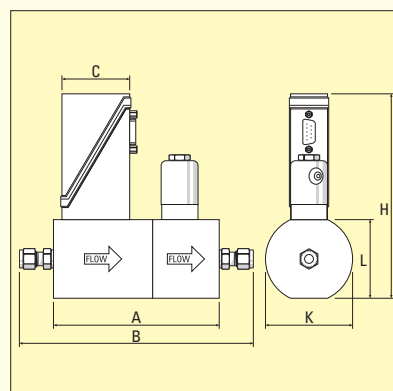
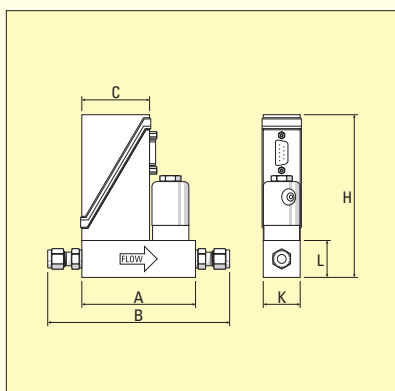
FIELDS OF APPLICATION

- Pilot plants.
- Process control in the food, chemical, petrochemical and pharmaceutical industries.
- Fermentation and bio-technology.
- Quality control and leak tests.
- Production of defined gas mixtures, e.g. calibration gases in the environmental analysis.
- Exhaust gas optimisation in fuel engines.
- Burner control.
- Semiconductor production.
- Plasma surface technology.
- Permeability research.
- Catalyst optimisation and test.

MODELS, DIMENSIONS AND WEIGHTS MASS FLOW CONTROLLER (MFC)

	Flow ranges ¹⁾		Pressure rating / model		
	smallest range	highest range	64 bar	100 bar	400 bar
With integral, direct acting Control Valve for normal operating conditions	0,02.....1 ml _n /min	0,15.....7,5 ml _n /min	F-200C	F-210CV	
	0,15.....7,5 ml _n /min	0,3.....15 l _n /min	F-201C	F-211C	
	0,2.....10 l _n /min (for H ₂ /He)	1,4.....70 l _n /min 2.....100 l _n /min	F-201AC	F-211AC	
For Low-ΔP applications ²⁾	0,2.....10 ml _n /min	0,3.....15 ml _n /min	F-200DV		
	0,3.....15 ml _n /min	0,03.....1,5 l _n /min	F-201D		
	0,03.....1,5 l _n /min	0,2.....10 l _n /min	F-201E		
	0,1.....5 l _n /min	0,6.....30 l _n /min	F-202D		
	0,6.....30 l _n /min	1.....50 l _n /min	F-202E		
For high-pressure, High-ΔP applications with Vary-P Valve ²⁾	0,2.....10 ml _n /min	10.....500 ml _n /min			F-230M
	10.....500 ml _n /min	0,2.....10 l _n /min			F-231M
	0,2.....10 l _n /min	2.....100 l _n /min			F-232M
For high flows with Pilot-Valve ³⁾	0,5.....25 l _n /min	5.....250 l _n /min	F-202AC	F-212AC	
	2.....100 l _n /min	25.....1250 l _n /min	F-203AC	F-213AC	

¹⁾ based on air, intermediate ranges are available.
²⁾ bigger flows possible with separate sensor and valve.
³⁾ up to 200 m³_n/h and 500 m³_n/h in industrial style.



Model	Dimensions (mm)						Weight (kg)
	A	B	C	H	K	L	
F-200CV/F-210CV	77	127	47	111	25	25	0,6
F-201C/F-211C	77	127	47	111	25	25	0,6
F-200DV/F-201D	77	127	47	111	25	25	0,6
F-201AC/F-211AC	77	131	47	123	25	37	0,7

Model	Dimensions (mm)						Weight (kg)
	A	B	C	H	K	L	
F-202AC/F-212AC	112	162	47	139	59	53	2,1
F-203AC/F-213AC	171	240	47	153	74	67	4,9
F-230M/F-231M	115	165	47	162	69	55	3,4
F-232M	115	165	47	162	69	55	3,4

All specifications are subject to change without notice.
 Certified drawings are available on application.

Dimensions and weights of other models are available on application.

TECHNICAL SPECIFICATIONS EL-FLOW®

MEASUREMENT SYSTEM

ACCURACY (AT CALIBRATION UNDER OPERATING CONDITIONS)	Standard 3F-Calibration: $\pm 0.8\%$ of reading plus $\pm 0.2\%$ of full scale Polynomial calibration: $\pm 0.5\%$ of reading plus $\pm 0.1\%$ of full scale
REPRODUCIBILITY	< 0.1% full scale
REPEATABILITY	< 0.2% of reading
RESPONSE TIME	1...2 sec. (faster on request)
CONTROL STABILITY	< $\pm 0.1\%$ full scale (typical for 1 l _n /min N ₂)
PRESSURE SENSITIVITY	0.1%/bar typ. N ₂ 0.01%/bar typ. H ₂
ATTITUDE SENSITIVITY	max. error 0.015% at 1 bar N ₂ and 90° change
VIBRATION SENSITIVITY	negligible
TEMPERATURE SENSITIVITY (see SEMI E 18-91)	zero point approx. 0.05% of full scale/°C span approx. 0.05% of reading/°C
SUPPLY VOLTAGE SENSITIVITY	zero at correct supply voltages (acc. to electr. data)
CONTROL VALVE	closes automatically at setpoint < 1%
LEAK INTEGRITY (see SEMI E 16-90)	tested < 2 x 10 ⁻⁹ mbar l/s He Additional pressure test at 1,5 times the max. stated operating pressure
RFI	CE approved design

MECHANICAL PARTS

PROCESS CONNECTIONS	see model number code; other on application
MATERIALS OF CONSTRUCTION	stainless steel AISI 316L or comparable
SEALS	Viton, EPDM, elast. PTFE, other on application
SURFACE QUALITY	Ra 0.2...0.6 µm

OPERATING LIMITS

RANGE	2%...100%
TYPES OF GASES	all gases compatible with AISI 316L
TEMPERATURE	-10 °C up to +70 °C
WARMING-UP TIME	30 min. for optimum accuracy, 2 min. for accuracy $\pm 2\%$ of full scale

ELECTRICAL PROPERTIES

SUPPLY VOLTAGE	mass flow meter +15 V...24 V, 50 mA mass flow controller +15 V, 250 mA -15 V, 30 mA mass flow controller +15 V, 250 mA mass flow controller +24 V, 190 mA
OUTPUT SIGNAL (SHORT CIRCUIT PROTECTED)	0...5 V, 0...10 V, min. load impedance > 2 kOhm 0 (4)...20 mA, max. load impedance < 375 Ohm
SETPOINT SIGNAL	0 (1)...5 V, 0...10 V, input resistance 1 MOhm 0 (4)...20 mA, input resistance 250 Ohm
REFERENCE SIGNAL	5 V (10 V), min. load impedance > 2 kOhm
ERROR DIAGNOSIS	by metering the valve voltage
ELECTRICAL CONNECTION	9-pin sub-D connector, cable length independent

■ CALIBRATION

References

The calibration is done with equipment certified by the Netherlands Measurement Institute (NMI) and is in accordance with the European and most important other countries' regulations.

System

Precision glass bore cylinders with mercury seal, or for higher capacities volumetric flow meters with temperature and pressure compensation.

Gases

If possible, every instrument is calibrated under its operating conditions. A number of standard gases are available. Otherwise N₂/air is used with conversion to operating conditions.

Gas data

A substantial data base is available for determining the physical properties such as density, viscosity and specific heat under operating conditions (usually not available in standard gas books). All this data is extremely important for the calculation of the conversion factor. The calculation is automatically performed in the calibration programme.

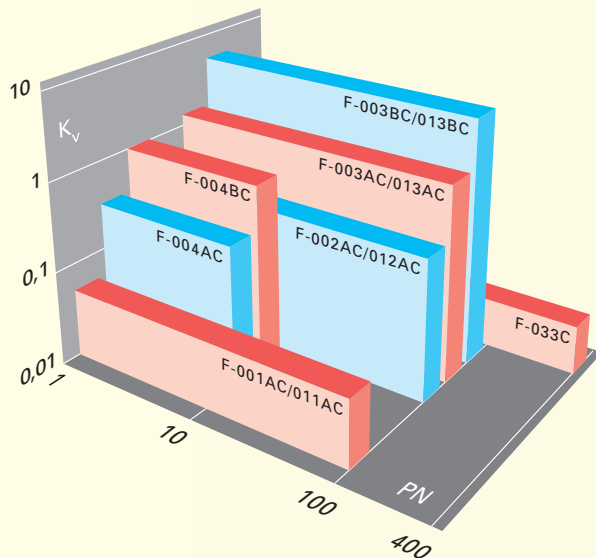


CONTROL VALVES

The control valve can be furnished as an integral part of an EL-FLOW mass flow controller, or as a separate component. It is a proportional, electro magnetic control valve with extremely fast and smooth flow control characteristics.

With reference to the specific fields of application there are different series of Bronkhorst Hi-Tec control valves. The optimum choice is made together with your distributor after having studied the operating conditions and requirements. But for those of you that want detailed information, the most important features of the various models are summarised here (see also the graph printed below).

GRAPHIC DISPLAY OF K_V AND MAX. PRESSURE



PRINCIPLE OF OPERATION

In the neutral position (no valve voltage supply), the control mechanism, a plunger/orifice system, is closed by means of a spring and the differential pressure. As soon as the controller supplies sufficient voltage, the magnetic force caused by the coil lifts the plunger, until the forces are in balance and the desired gas flow rate is maintained. The valve is normally closed. In the normally opened version the plunger/orifice control mechanism is closed by the ΔP and the magnetic force.

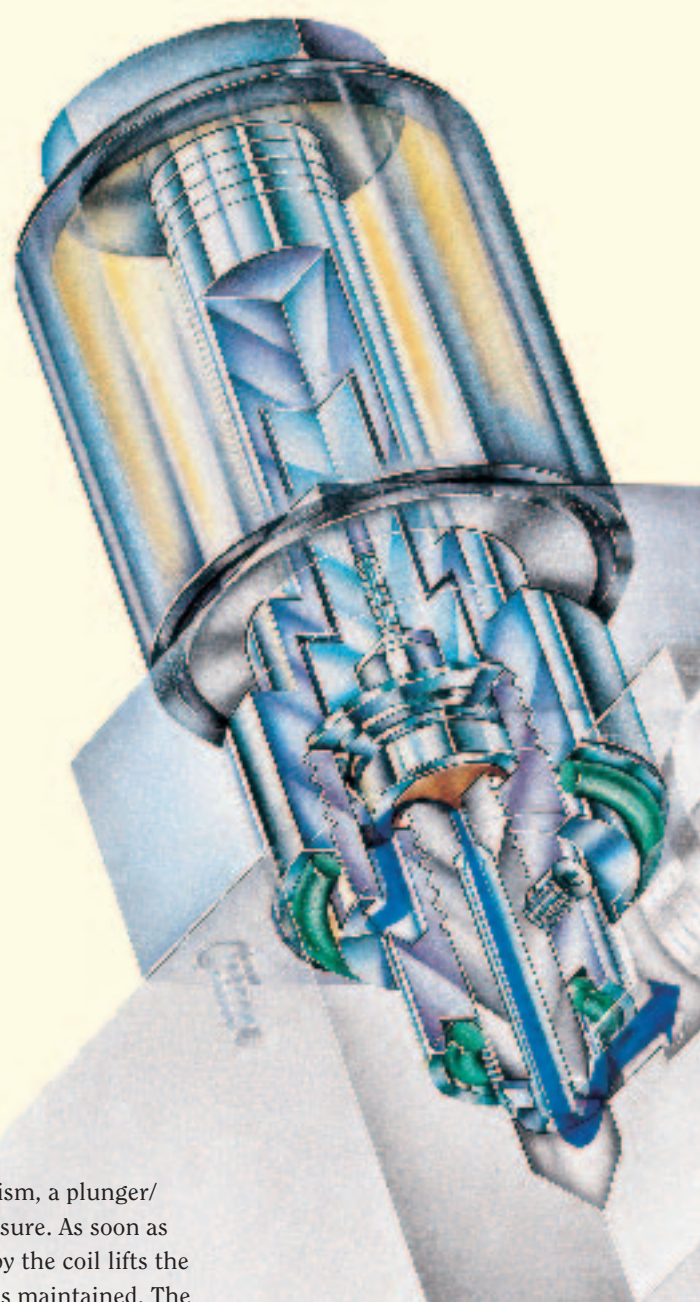
SUMMARY OF TYPES AND MODELS

Type	Model	K_V max.	ΔP min.	ΔP max.	PN
direct acting	F-001AC, F-011AC	$6,6 \times 10^{-2}$	-	3,6...50 bar *	100
Vary-P	F-033C	$5,1 \times 10^{-2}$	6 bar	400 bar	400
Pilot-operated	F-002AC, F-012AC	0,4	1,3 bar	20 bar	100
	F-003AC, F-013AC	1,5	1,6 bar	20 bar	100
	F-003BC, F-013BC	6,0	1,6 bar	20 bar	100
Bellows	F-004AC	0,3	-	5 bar	10
	F-004BC	1,0	-	5 bar	10

*) depending on K_V -value.

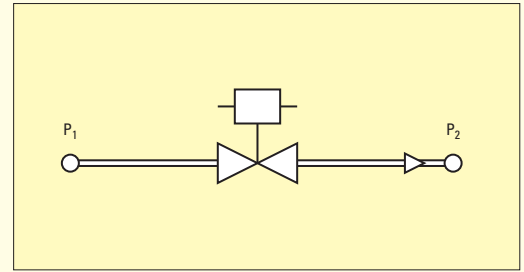
ADVANTAGES

- Modular.
- Compact.
- Simple.
- Electro-chemically polished.
- User replaceable.



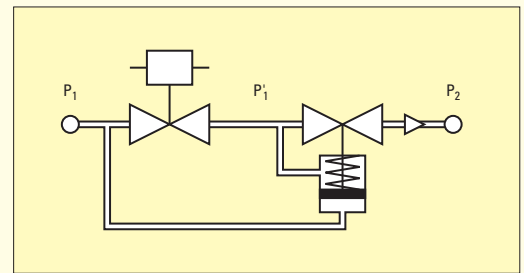
▶ DIRECT ACTING VALVE F-001AC

The valve consists of a valve module (see picture) that is mounted inside a base block. The base block may constitute a separate control valve F-001AC, or an MFC (F-200CV, F-201C, F-201AC). The valve module is also used as pilot valve in bigger valves and controllers.



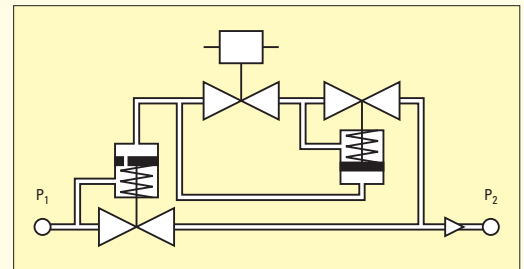
▶ VARY-P VALVE F-033C

This is a patented 2-phase control valve. The flow control section is the valve module as described above. The other section is a pressure compensation valve; the latter maintains a constant ΔP across the first section ($P_1 - P_1'$) of 4 bar. By doing so both the inlet pressure P_1 and the outlet pressure P_2 may change without having any impact on the Vary-P Valve function.



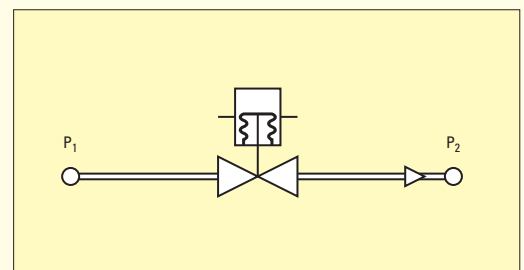
▶ PILOT-OPERATED VALVES F-002AC, F-003AC, F-003BC

are patented indirect acting control valves and use a complete Vary-P Valve as described above, as pilot valve. Hence they are also pressure compensated. The pilot controls the pressure on the back side of a spring loaded cylinder, of which the front side is subject to the inlet pressure of the main valve. This cylinder furnishes the power for the main valve. As soon as the ΔP becomes bigger than the spring force, the main valve, will open.

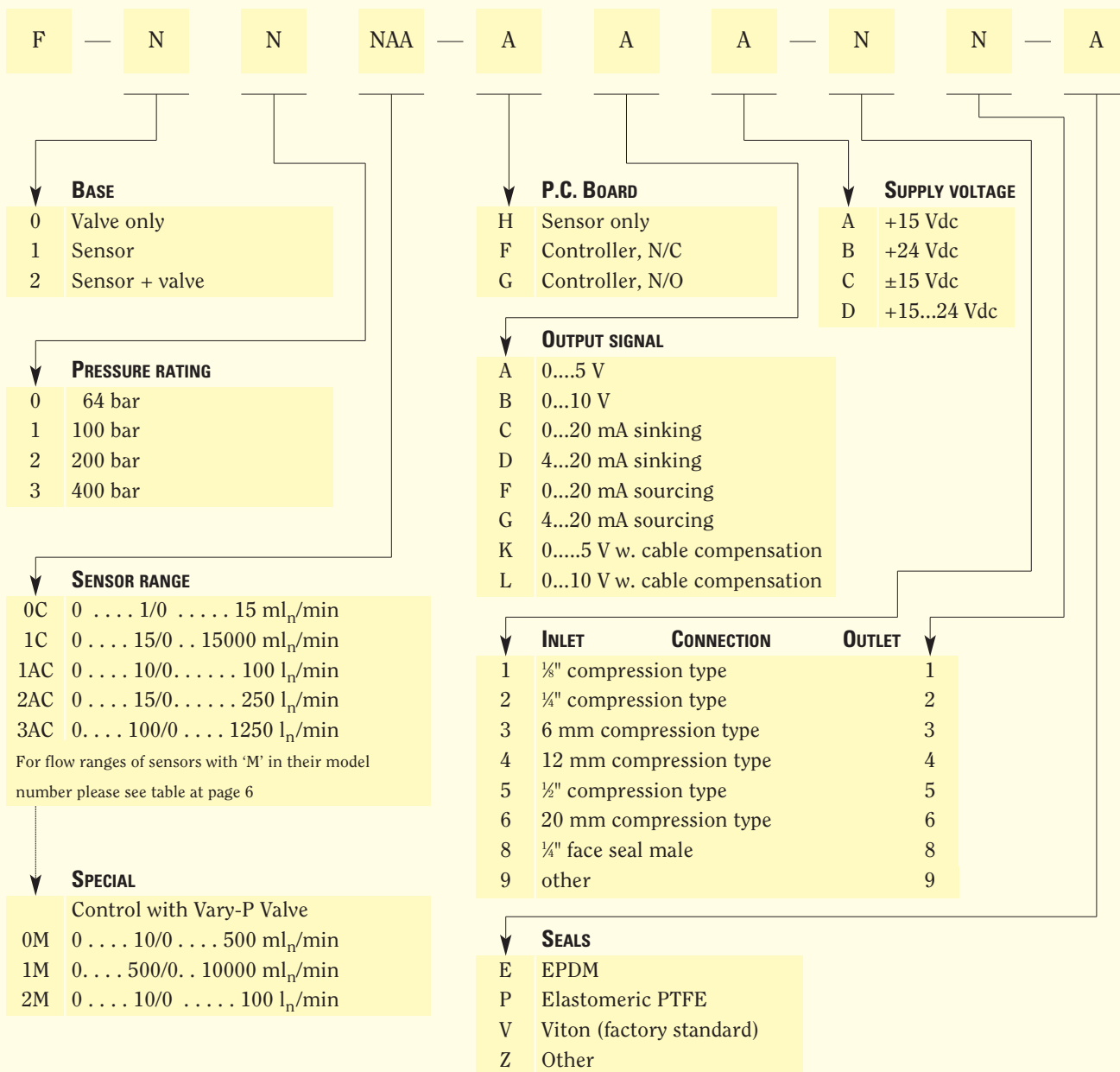


▶ PRESSURE COMPENSATED BELLOWS VALVES F-004AC/F-004BC

are direct acting control valves as the above-mentioned F-001AC series. They are also closed by spring force. A bellows compensates the closing force acting on the plunger to such a degree that only a very small magnetic force is required and in this way large orifices can be opened, which is impossible in the F-001AC design as it would cause oscillation. The bellows pressure compensated design, however, enables us to smoothly control large flows at extremely low pressures.



MODEL NUMBER IDENTIFICATION



The model number code serves primarily to identify instruments. When making enquiries or placing orders we determine the correct model number in accordance with the following

Enquiry and ordering information.

In order to furnish the optimum instrument for your application we request you to state: type of gas, flow range, operating temperature and pressure (for controllers supply pressure and back pressure), electrical connection, desired output signal, type of process connection and seals.

Based on this information we perform the following actions/calculations:

- Convert the desired flow to N₂-equivalent flow, i.e., divide the desired flow by the conversion factor as calculated by FLUIDAT.
- Only for controllers, check if the pressure differential across the valve (ΔP) is within the limits.
- Only for controllers, check if the FLUIDAT calculated K_v-value is within the specifications allowed.

EL-FLOW[®] DIGITAL MASS FLOW METER/CONTROLLER

GENERAL

Mass flow meters and controllers of the EL-FLOW series are also available in a digital version. As is often the case, mass flow meters in their standard analog construction are then furnished with AD/DA converters and so made digital. Not so in our case.

EL-FLOW digital is based on a new digital PC-board on which the sensor signal is sent direct to a micro processor. By doing so an optimum signal stability and accuracy is achieved. An integral alarm function continuously checks the difference between the setpoint- and the measured value. If, for example, the supply pressure of a mass flow controller drops and therefore the flow can no longer be controlled, the instrument gives a warning. In addition the instrument checks itself through an integral, self diagnosis routine.

MULTI-BUS TECHNOLOGY

Bronkhorst High-Tech B.V. developed their latest digital instruments according to the 'multi-bus' principle. The basic PC-board on the instrument contains all of the general functions needed for measurement and control. It has analog I/O-signals and also an RS-232 connection as a standard feature. In addition to this

there is the possibility of integrating an interface board with DeviceNet[™], Profibus-DP[®], Modbus or FLOW-BUS protocol. The latter is a fieldbus based RS485, specifically designed by Bronkhorst High-Tech B.V. for their mass flow metering and control solutions, and through which the company already has fifteen years of experience with digital communication.

To support PC/PLC controlled process control Bronkhorst High-Tech has devised various software programmes, for instance a DDE-server for parameter exchange with MS WINDOWS application programmes. Furthermore Bronkhorst High-Tech offers free software tools for fieldbus connection and for monitoring, optimizing and operation of digital instruments.

SPECIFICATIONS

Digital Mass Flow Meter/Controller

- Digital input/output (DeviceNet[™], Profibus-DP[®], Modbus or FLOW-BUS operation) or analog (0...5 (10) V, 0 (4)...20 mA).
- Interchangeable with analog instruments.
- Accuracy: $\pm 0,5\%$ of reading plus $\pm 0,1\%$ of full scale.
- Storage of up to 8 calibration curves.
- In-situ self-diagnosis.
- Alarm and counter functions.
- Fast (adjustable) response controller.
- Single rail power supply +15...+24 Vdc.

SOFTWARE SUPPORT

Bronkhorst Hi-Tec offers free software support for personal computer or PLC.

- FlowDDE: Software tool to interface between digital instruments and windows software.
- FlowPlot: Software tool for monitoring and optimizing digital instruments parameters.
- FlowView: Software tool to operate Bronkhorst digital instruments.
- FlowFix: Software tool for fieldbus connection of digital instruments.



EL-FLOW DIGITAL MFC

LOW- Δ P-FLOW MASS FLOW METER/CONTROLLER

LOW- Δ P-FLOW mass flow meters and controllers were developed based on the proven concepts of the EL-FLOW series.

Special constructions of both the sensor and the flow splitter make the LOW- Δ P-FLOW series especially suitable for applications where only an extremely low pressure drop is allowable. In this instrument the sensor requires 0,5...5 mbar.

This is achieved thanks to a different laminar flow device that produces laminar flow through an annular area. The enlarged unobstructed flow channel with the low pressure drop also decreases the risks of deposits,

condensation or blocking, and facilitates purging and cleaning of the instruments. The application of the LOW- Δ P-FLOW series is thus also preferred when using very corrosive gases, even when a low pressure drop is as a primary requirement not so important.



In addition to the measurement, Bronkhorst High-Tech has developed control valves for the control of higher flows as described on page 11 with pressure compensated bellows, models F-004AC and F-004BC for extremely low Δ P, starting from approx. 1 mbar to 5 bar, depending on K_v selection.

The LOW- Δ P-FLOW instruments are described in a separate brochure in detail.

FLOW RANGES (BASED ON AIR, INTERMEDIATE RANGES ARE AVAILABLE)

Mass Flow Meters				Mass Flow Controllers			
Series F-100D	min.	0,2	.....10 ml _n /min	Series F-200DV	min.	0,2	.....10 ml _n /min
	max.	0,3	.....15 ml _n /min		max.	0,3	.....15 ml _n /min
Series F-101D	min.	0,3	.....15 ml _n /min	Series F-201D	min.	0,3	.....15 ml _n /min
	max.	0,1	.....5 l _n /min		max.	0,1	.....5 l _n /min
Series F-101E	min.	0,03	.....1,5 l _n /min	Series F-201E	min.	0,03	.....1,5 l _n /min
	max.	0,2	.....10 l _n /min		max.	0,2	.....10 l _n /min
Series F-102D	min.	0,1	.....5 l _n /min	Series F-202D	min.	0,1	.....5 l _n /min
	max.	0,6	.....30 l _n /min		max.	0,6	.....30 l _n /min
Series F-102E	min.	0,6	.....30 l _n /min	Series F-202E	min.	0,6	.....30 l _n /min
	max.	1,0	.....50 l _n /min		max.	1,0	.....50 l _n /min
Series F-103D	min.	0,6	.....30 l _n /min				
	max.	2,0	.....100 l _n /min				
Series F-103E	min.	2,0	.....100 l _n /min				
	max.	4,0	.....200 l _n /min				
Series F-106Z	min.	0,2	.....10 m ³ _n /h				
	max.	20	.....1000* m ³ _n /h				

*) higher on application.

COMBI-FLOW INSTRUMENTS WITH METAL SEALS

The instruments of the COMBI-FLOW series are characterised by the fact that there is only one metal-to-metal seal per module; this seal maintains its tightness over and over again.

They distinguish themselves by a high surface quality and are therefore especially suitable for meeting the semi-conductor industry requirements as well as other high purity gas applications. The base block of the modules is identical for each different function (except the on-off valve function) and can be put in series by using either vacuum couplings or welded connections.

AVAILABLE MODULES

Mass Flow Meter

for flows between
0,2...10 ml_n/min
and 2...100 l_n/min.

Pressure Transducer

with piezo-resistive pressure
sensor for pressure ranges
between 6...300 mbar and
0,2...10 bar absolute or relative.

Filter

as ultra pure PVDF fine filter
0,05 µm or sintered stainless
steel filter 0,5, 2, 7 or 15 µm.

Control Valve

normally closed or open, for
flow or pressure control with
 $K_v \text{ max. } 4,9 \times 10^{-2}$.
Maximum temperature 70 °C.

On/Off Valve

pressure activated, NO or NC.

The COMBI-FLOW instruments are described in a separate brochure in detail.



THE SPECIAL BRONKHORST HIGH-TECH ACHIEVEMENTS

The present technical level of the Bronkhorst Hi-Tec products is the result of a number of basic patents and a substantial research and development effort, for which approx. 17% of the revenues have been invested year after year for 20 years. In addition to this there is a close co-operation with universities and major research centres in basic physics and, not in the least, with innovative users with ever increasing requirements.

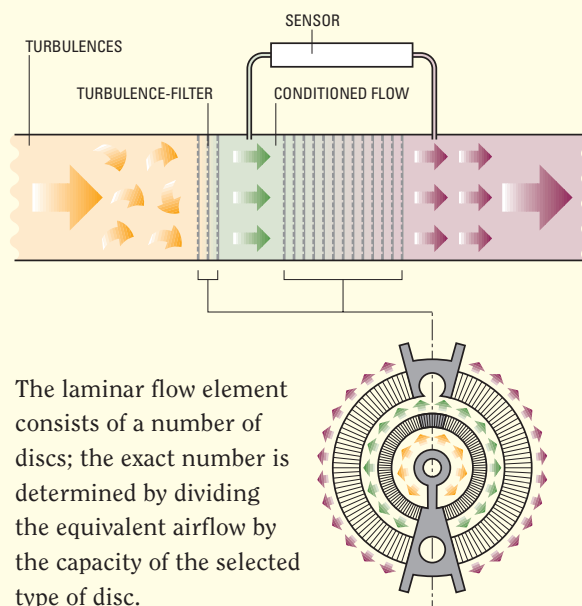
The ISO 9001 qualification in 1992 was a logical consequence of the company's high standards in quality control and documentation. The same holds good for meeting the requirements of EMC, the CE qualification and ISO 14001 certification for environmental standards.

■ LAMINAR FLOW ELEMENT

The thermal mass flow meters that are now on the market do not really distinguish themselves from one another in the measuring principle (see page 5), however, they do in creating the laminar flow required for the correct measurement. Only the by-pass flow through the capillary is always measured (see picture). In this capillary the flow is always laminar thanks to its inherent dimensions.

The quality of the measurement is largely dependent of how perfect the main gas stream flow can be made laminar. With this point lies one of the special achievements of Bronkhorst High-Tech. The patented laminar flow element consists of stainless steel discs, with precision-etched flow channels.

The flow characteristics of each etched channel are comparable to those of the measuring capillary. Each disc thus has a fixed flow capacity, equal to the number of channels multiplied by the flow through the measuring capillary (approx. 10 ml_n/min air).



The laminar flow element consists of a number of discs; the exact number is determined by dividing the equivalent airflow by the capacity of the selected type of disc.

The discs are combined in such a way, that there is always an identical pressure drop across the total laminar flow device at maximum flow. Therefore the laminar flow devices are interchangeable and moreover the flow range of an instrument can be easily changed if so required. (See capacity tables).

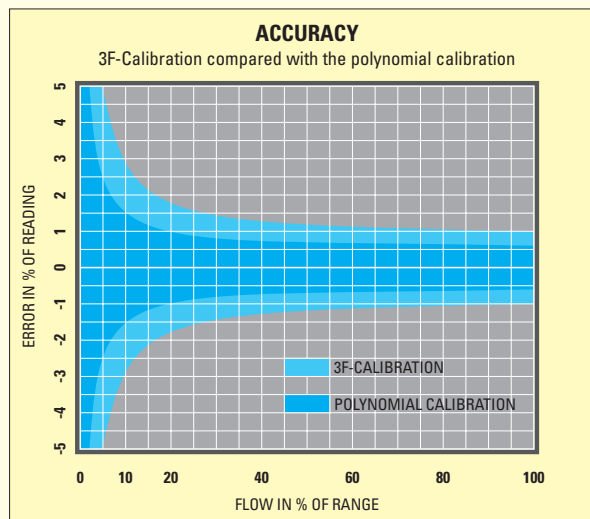
■ CALIBRATION AND ACCURACY

Each instrument is calibrated under actual operating conditions whenever possible. A number of standard calibration gases is available. Otherwise the FLUIDAT database is used. Thanks to the perfect flow-split between by-pass flow and main flow, achieved by the patented laminar flow elements, and the knowledge of the heat profile of the sensor and viscosity effects it is possible with FLUIDAT to predict a much more accurate conversion factor. For this precise calibration method Bronkhorst High-Tech introduced the "3F Calibration Procedure" (3F stands for "FLUIDAT FINE FIT"). It is far superior to other previously used conversion factors and comes closest to actual calibration.

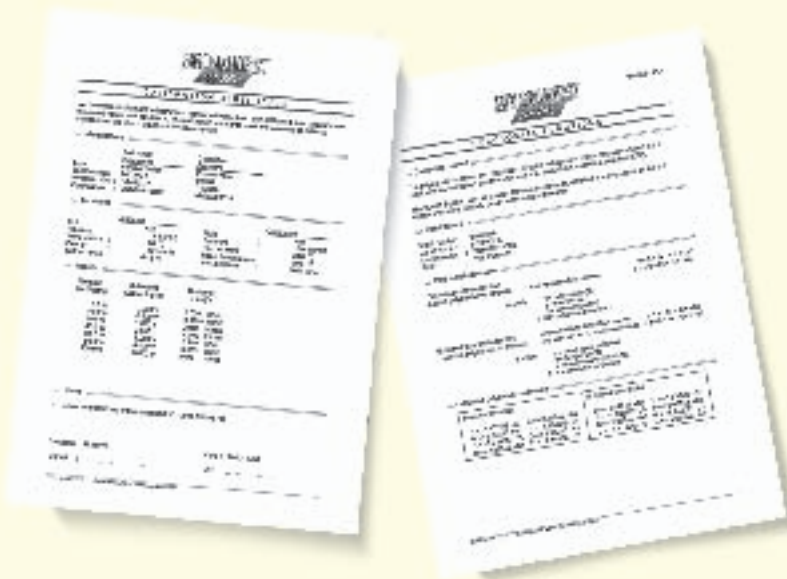
High repeatability and reproducibility of the output signal are also worth mentioning. In some applications these values can be more important than the absolute accuracy.

Recently, however, the need for higher absolute accuracies has been growing in view of ISO 9001 certifications, and the inherent need for calibration of instruments used for quality control purposes.

For applications where high absolute accuracy is a must, Bronkhorst HighTech have devised the "Polynomial Calibration". With this method the accuracy can be improved to $\pm 0,5\%$ of measured value plus $\pm 0,1\%$ of full scale value when calibrating under actual conditions.



With each Bronkhorst Hi-Tec mass flow meter or controller a calibration certificate, example shown, is supplied. The user can thus convince himself that the specified tolerances are met. And it enables him to check, if after a certain period, the original values are still maintained or if a re-calibration is required.



Example of a Calibration Certificate with appendix for Polynomial Functions

SOFTWARE FLUIDAT

The FLUIDAT software of Bronkhorst High-Tech consists of a database of information about more than 600 fluids, and two application programs: Flow Calculations and Physical Properties. We invite you to visit our internet site www.fluidat.com for free registration.

FLOW CALCULATIONS

This program offers the possibility to perform various calculations that are important for Bronkhorst Hi-Tec instruments such as:

- Calculation of K_v -value and the orifice bore of control valves.
- Conversion factors.
- Pressure drop over pre-filters.

These calculations can be made for pure gases, gas mixtures, at all pressures and temperatures applicable to Bronkhorst Hi-Tec products.

PHYSICAL PROPERTIES

This program is not necessarily limited in its application to the users of Bronkhorst Hi-Tec instruments. The following physical properties can be determined:

- Density.
- Viscosity, kinetic and dynamic.
- Specific heat at constant pressure (C_p).
- Specific heat at constant volume (C_v).
- Thermal conductivity.
- Boiling point.
- Vapour pressure curves.

CUSTOMER SERVICE

Bronkhorst High-Tech and its distributors do not stop with commercially solving your measurement problem. We also offer:

- Support in start-up if so required.
- Seminars and training.
- Maintenance plan proposals if so desired.
- Instrument check, repair, re-range and calibration in our service centres.
- Short turnaround times.
- Field service (inclusive of calibration).
- Factory tours.

READOUT SYSTEMS WITH INTEGRATED POWER SUPPLY

THE WIDE SELECTION IN READOUT SYSTEMS

Is another special achievement of Bronkhorst High-Tech. Nowhere are there so many alternatives. Because of that a tailor-made total solution is possible.

The readout systems make much more possible than providing command signals to a number of controllers, for instance for making defined gas mixtures. The parameter to be controlled by the flowrate can also be temperature, process pressure, pH-value, and the command signals for these can be directly provided to the flow control loop. In combination with computers or P.L.C. ramp functions or other programmable process phases can be realised .

This brochure does not lend itself to show all the possibilities how to build control systems; your local distributor will gladly discuss your particular application with you in detail.

FLOW-BUS SINGLE CHANNEL MODULE

Series E-7000

The digital single channel control module was developed by Bronkhorst HighTech B.V. for mass flow measurement and control systems. Its application is not limited to operation in combination with Bronkhorst Hi-Tec mass flow controllers and pressure controllers, but it can also be used with other transmitters or transducers, or in master/slave control systems.

The Bronkhorst Hi-Tec FLOW-BUS Series E-7000 offers the user a menu driven device with the possibility to define and control mass flow meters/controllers, pressure transducers/controllers or other instruments.

The μ -processor based single channel module offers the possibility to show tag numbers, measurement identifications, fluid names and totalizing units on top of the measurement and command signals in percent of max. flow or direct reading units.

In addition there is the feature to programme the polynomial function of the calibration curve to obtain an accuracy of $\pm 0,5\%$ of the measured value plus $\pm 0,1\%$ of full scale.



E-7000 SINGLE CHANNEL MODULE

Features

A user-friendly indication/control/alarm/totalization module, menu driven with 5 push buttons for:

- Use with digital or analog instruments.
- Indication of measured value on 2-line, 16-figure display in percent or direct indication, combined with totalized quantity or preset quantity.
- Internal/external command.
- Master/slave control.
- Totalization or batch functions.
- Programmable alarm functions.
- NO/NC relays for status outputs.
- Programming of polynomial function.

■ FLOW-BUS MULTI-CHANNEL CONFIGURATIONS

Based on the single-channel module it is easy to form multi-channel units. Three channels fit in a ½ 19" housing and 6 channels can be housed in a 19" table top or rack mounting unit.

Specifications

Housing:

- Cassette for panel mounting (1 channel)
96 x 144 mm.
- Table top housing (1 channel) 76 x 134 x 260 mm.
- Table top or rack housing (max. 3 channels)
3 HE ½ 19".
- Table top or rack housing (max. 6 channels)
3 HE 19".

Electrical Data

- Power supply 100...240 Vac, 50...60 Hz or 24 Vac/Vdc.
- Output signals/command signals 0...5 (10) Vdc,
0 (4)...20 mA.
- Sub-D Connector for instrument connection.
- Sub-D Connector for analog I/O functions.
- Sub-D Connector for connection to FLOW-BUS
(RS-485 interface).
- Max. power consumption + 15 Vdc 1,5 A,
- 15 Vdc 150 mA.

■ FLOW-BUS DIGITAL READOUT SYSTEM

Series E-7002

This series comprises modular readout systems built up from E-7000 and E-5700 modules.

Tailer-made systems with non-standard functions are also counted to this series.



E-7100 3-CHANNEL EXECUTION

READOUT SYSTEMS WITH INTEGRATED POWER SUPPLY

ANALOG STANDARD READOUT SYSTEMS

Series E-5700

This series comprises standard types for use with analog mass flow meters and controllers. The most commonly used function are offered. Those who do not yet work digitally, find here the successors of the E-5512, E-5513 and E-5514, which were sold by the thousands.

- E-5752: 2-channel system, table top model.
- E-5762: 2-channel system, for panel mount (96 x 144 mm).
- E-5712: 2-channel system, ½ 19" table top model.
- E-5732: 2-channel system, ½ 19" for rack mounting.
- E-5714: 4-channel system, ½ 19" table top model.
- E-5734: 4-channel system, ½ 19" for rack mounting.
- E-5716: 6-channel system, ½ 19" table top model.
- E-5736: 6-channel system, ½ 19" for rack mounting.

Functions:

- 1 indicator per 2 channels, with selector switch.
- 1 setpoint potentiometer per channel.
- 1 internal/external command signal switch.
- 100...240 Vac power supply.



E-5752 2-CHANNEL PS/READOUT

Electrical data:

- Power supply 100...240 Vac.
- Suitable for connection of instruments with output signal 0...5 (10) Vdc.
- Ext. output and/or setpoint signals: 0...5 (10) Vdc; 0 (4) ...20 mA (to be advised).
- Sub-D socket for instrument connection.
- Sub-D socket for analog I/O function.
- Max. power +15 Vdc, 2 A / -15 Vdc, 300 mA.



E-5736 6-CHANNEL PS/READOUT

USEFUL ACCESSORIES

■ FILTERS

General

Thermal mass flow meters and controllers for gases are sensitive to contamination, which is inherent to their construction. To improve the MTBF (Mean Time Between Failure) it is necessary to use clean gases.

As this is not always the case, Bronkhorst High-Tech offers 2 types of filters:

COMBI-FLOW Filter

The constructional properties have already been described on page 15. The filter element can be replaced without having to remove the filter housing from the pipeline.

Features:

- Compact construction.
- Metal sealed.
- Orbitally welded.
- Electro-polished.
- Ultrasonically cleaned.
- Cleanroom assembled.
- Helium leak tested.

IN-LINE Filter

The IN-LINE filter is screwed into the inlet of the instrument to be protected. The filter element is also replaceable, however, the filter housing must be removed from the pipeline.

There are two types of filter elements for the filters:

PVDF Fine Filter

For the semi-conductor industry and similar high purity requirements applications for gases with a particle retention rate > 0.003 (m of more than 99.9999999%).

Sintered Stainless Steel Filter (ANSI 316L)

For general purpose applications, filter elements available between 0,5 and 40 µm.

Detailed specification sheets are available on application. When ordering filters the calculation of the pressure drop with FLUIDAT-software is a standard Bronkhorst High-Tech service.

■ MIXING CHAMBER/EVAPORATOR

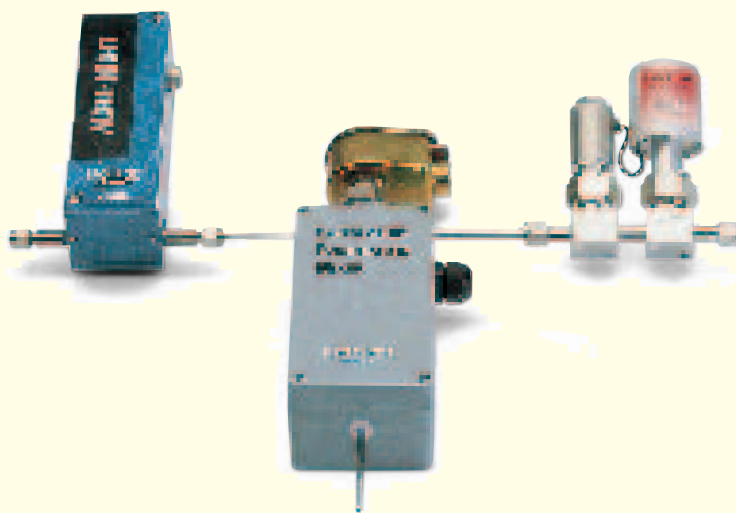
Gas Mix Chamber

Mixing gases is not simply a matter of putting together 2 or more gas streams. Bronkhorst High-Tech has developed a unique gas mixing chamber enabling the user to obtain a homogeneous gas mixture.

CEM Controlled Evaporation Mixer

In applications where the components to be mixed were liquids and gases, in the past, a carrier gas was used to be lead through a bubbler; the carrier gas would subsequently take up a certain vapour concentration. Later "Vapour Source Controllers" were also used. All users know of the difficulties to be mastered when working with fluids with low vapour pressures or different vapour pressures of the various components.

It was logical for Bronkhorst High-Tech to explore a completely new method after successful introduction of the LIQUI-FLOW® thermal mass flow meter/controller for measuring liquids. A system was devised where a small liquid flow is fed to a newly developed and patented mixing chamber in which the flow is directly controlled and mixed with the injected carrier gas. Subsequently this gas/vapour/liquid mixture is led to a temperature controlled heat exchanger to achieve complete evaporation.



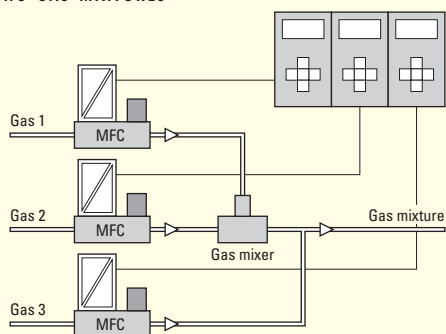
This method of making vapour concentrations in a carrier gas is fast, reproducible and very accurate. This has been recognised by the market. Please ask for more information if this subject is of interest to you.

EXAMPLES OF SOME APPLICATIONS

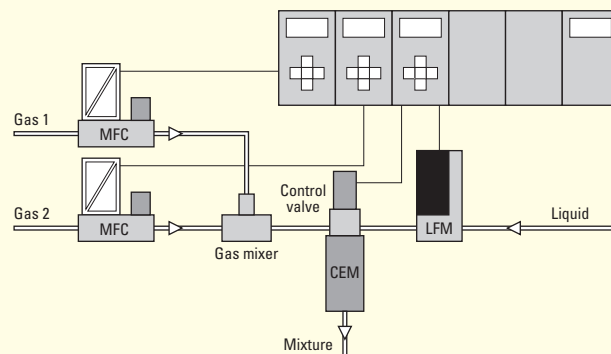
It is of course impossible to picture the possible number of applications. Here is a limited quantity of basic examples, which are often seen with some variations. However, identical or similar configurations are used in

totally different applications. Therefore please consider these examples and their titles as an inducement for solving certain problems.

MAKING GAS MIXTURES



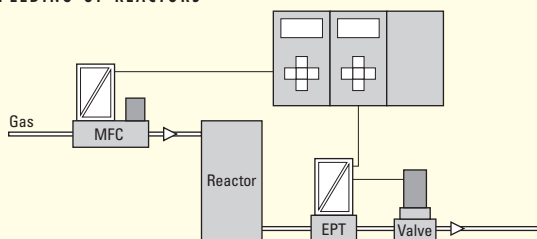
Making a mixture of 3 gases; the measuring range of gas 1 is much smaller than the other two and therefore the gas mixer takes care of a homogeneous gas mixture.



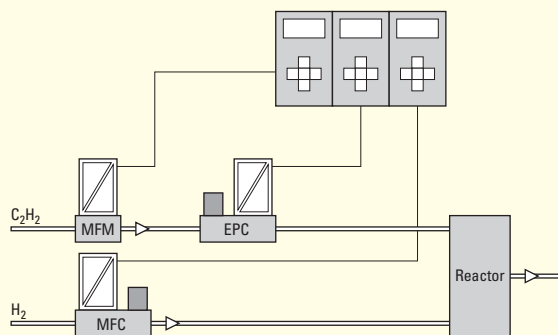
Control and subsequent evaporation of a liquid to a gas mixture. Principle fields of application:

- Surface treatment technology.
- Semi-conductor industry.

FEEDING OF REACTORS

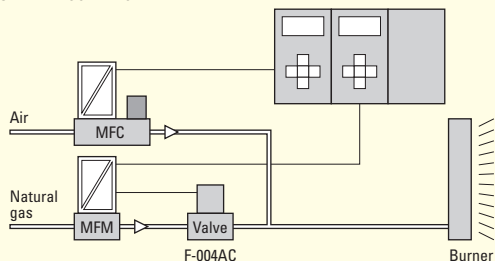


Flow control combined with the control of the reactor pressure.

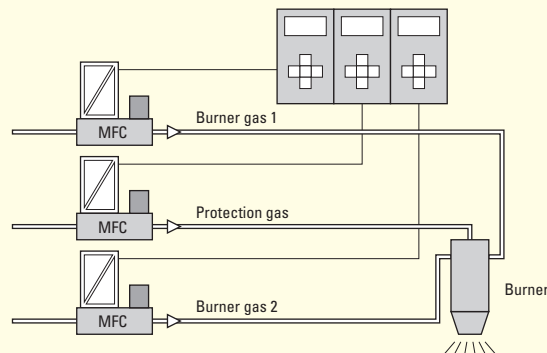


Mixture control, combined with pressure control or limitation for one of the components. (In this example because of the critical maximum pressure of C_2H_2 .)

BURNER CONTROL



Gas/Air mixture control with a separate special control valve suitable for controlling relatively large flows with extremely low differential pressure.



Typical example for welding gas burner with protective gas.

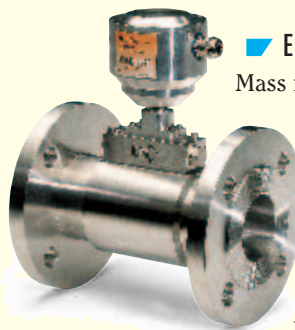
OTHER BRONKHORST HI-TEC PRODUCTS

In addition to the instruments of the EL-FLOW® series described in this catalogue the LOW- Δ P-FLOW and COMBI-FLOW were mentioned. We would also like to identify some other product groups within our range of instruments and their corresponding brochures:



IN-FLOW

Mass flow meters and controllers for gases suitable for more industrial applications, especially thanks to their IP 65 protection. Not only can the EL-FLOW® and LOW- Δ P-FLOW series described in this catalogue be supplied in this way, but moreover instruments can be supplied suitable up to 11000 m³_n/h as described in the IN-FLOW brochure.



EX-FLOW

Mass flow meters and controllers for gases in rugged construction with approval for use in hazardous areas. The measuring ranges are from 0,15...7,5 ml_n/min up to 220...11.000 m³_n/h. The mass flow meter has ATEX approval according to II 2 G EEx ib II C T4.

The electronic housing is IP65. The control valves have K_v-values between 5,7 x 10⁻⁵ and 6,0 and approvals to ATEX II 2 G/D IP6X T 130°C EEx me II T4 and II 1 G/D EEx ia IIC T6



EL-PRESS

Pressure transducers and controllers for gases and liquids are built along the same lines as the EL-FLOW® instruments. The only difference is that there is no laminar flow device, and the flow sensor is replaced by a piezo-resistive pressure transducer.

The measuring ranges are between 2...100 mbar abs. or relative, and 8...400 bar. Upstream or downstream pressures up to 100 bar are controlled with integrally mounted control valves.

For higher pressures separate control valves are used.



LIQUI-FLOW®

Mass flow meters and controllers for liquids in ranges between 0,1...5 g/h and 0,4...20 kg/h (water equivalent). LIQUI-FLOW® flow meters only require a small differential pressure. In spite of measurement without a by-pass the rise in temperature of the fluid is minimal; only approx. 1...5 °C.

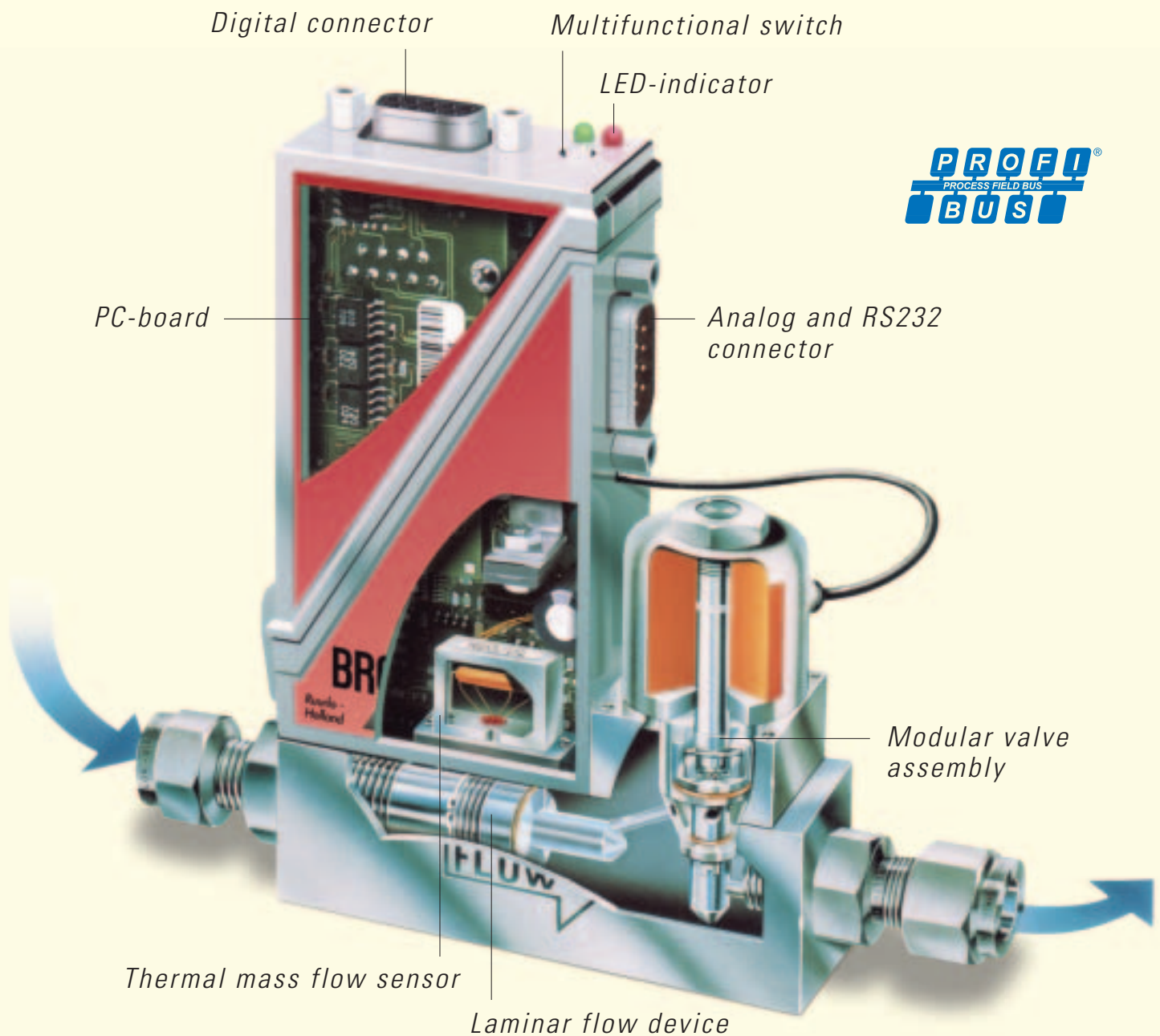
This greatly limits the danger of evaporation or degradation of the fluid. For even smaller ranges Bronkhorst High-Tech offers the μ -Flow series; smallest range: 12,5...250 mg/h (water equivalent).

If one or more instruments described here are of interest to you, then please do not hesitate to contact your distributor.

EL-FLOW[®]

MODEL F-201C

DIGITAL MASS FLOW CONTROLLER



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HI-TEC

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