

LIQUI-FLOW[®]

MASS FLOW METERS AND CONTROLLERS FOR LIQUIDS



THRU-FLOW MEASUREMENT

NO ELASTOMER SEALS, WELDS ONLY

ONE METAL SEAL IN CONTROLLER

ONLY 1°C RISE IN SENSOR

SUPER STABLE ZERO

STERILIZABLE

ATTITUDE INSENSITIVE

BRONKHORST
HI-TEC

BRONKHORST HIGH-TECH B.V.



PRODUCTION AND SERVICE IN EUROPE, NORTH AMERICA AND ASIA

■ The company was formed in 1981 and has been established at Ruurlo, Netherlands since 1983. Today it offers the broadest range of thermal mass flow equipment in the world.

There are instruments for laboratory applications, general industrial use and ex-proof installations. Satisfied customers, state-of-the-art innovations and a high product quality have always been the cornerstones of the success of Bronkhorst High-Tech. In 1987 the company was awarded the prestigious 'King-William I' award for young, successful enterprises. In 1992 it qualified for ISO 9001 certification and in 1995 the company was certified ISO 14001 for meeting the international standards for environmental management.

Bronkhorst High-Tech have signed agreements with Porter Instruments Company, USA and with Oval Techno Corporation, Japan in order to ensure that similar products are manufactured close to the users. Service and repairs are also available from these locations.

The sales and service organisation in Europe is shown on the right hand page. The number of service stations is expanding rapidly to better support our customers.

Furthermore Bronkhorst High-Tech is represented in the following overseas countries: Australia, New Zealand, Israel, India, South-Africa, Korea and Brazil.



- SALES REPRESENTATION
- SALES REPRESENTATION WITH SERVICE AND CALIBRATION

This brochure describes the instruments of the LIQUI-FLOW® series, models L1 and L2. These liquid flow meters can be converted in liquid flow controllers, models L1C2 and L2C2, by adding control valves. The LIQUI-FLOW® models L30 and L30C2 for higher flow ranges are described in a separate leaflet. Furthermore your local distributor will gladly advise you on the μ-FLOW series Mass Flow Meters and Controllers for ultra-low liquid flow ranges.

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OBJECTIVE, APPROACH AND RESULT

OBJECTIVE

Bronkhorst High-Tech has had many years' experience in the field of micro to low flow liquid metering applications with the first commercially available thermal liquid mass flow meters and controllers in markets such as:

- Semiconductor
- Biotechnology
- Pharmaceutical
- Surface Treatment
- Chemical
- Petro-Chemical

Based on this experience our objective was to design a universal instrument for micro and low flow liquid measurement and control applications to feature:

- Quality
- Reliability
- Stability
- Serviceability

APPROACH

A product improvement engineering programme of the first generation of thermal liquid mass flow meters and controllers, instruments with a 20°C rise in temperature in the sensor and related attitude sensitivity, would surely not have led to the optimum solution.

Therefore a completely new generation of thermal liquid mass flow meters and controllers was developed in co-operation with TNO's Institute of Applied Physics (TPD)*.

* *The TNO Institute of Physics (TPD) is one of the R&D institutes of TNO, the Dutch organization for Applied Scientific Research with 5100 employees and an annual turnover of more than EUR 300 million. TNO is the largest independent R&D organization in the Netherlands and one of the largest in Europe.*

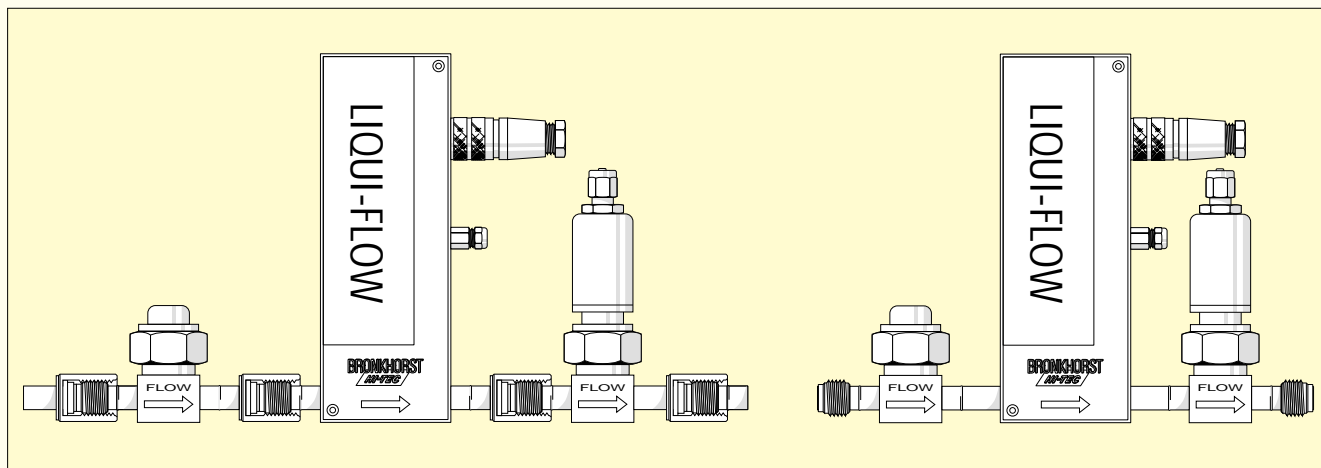
RESULT

The result of this joint engineering effort, LIQUI-FLOW®, fully meets the required standard of performance, is not affected by mounting position or entrained gas in the liquid, and offers access to wide fields of application; from vacuum up to 400 bar; from 0,1 g/h up to 1000 g/h.

The instrument basically consists of an AISI 316L stainless steel tube without any built-in obstructions, internal diameter approx. 1 mm, and along the tube wall a sensor/heater arrangement. All is contained within a cast aluminium IP65 weather tight housing, including signal conditioning and control electronics. The housing serves as a heat shield as well as a Faraday's cage for EMI protection.

Flow control is achieved by coupling to the meter a COMBI-FLOW control valve with a purge connection on top of the sleeve, so as to eliminate air or gas when starting up the system. The electronic control function forms part of the normal circuitry in the meter.

MALE/FEMALE INTERCONNECTION



WELDED INTERCONNECTION

FEATURES AND MEASURING PRINCIPLE

Bronkhorst High-Tech is proud to introduce the LIQUI-FLOW®. The product line is based on many years' experience and has been engineered with great care and attention to detail. The mass flow meter has features such as:

- Thru-Flow measurement
- 1°C temperature rise in sensor
- Super stable zero
- Wide flow ranges 1 : 50
- Sterilizable
- Voltage regulation
- Temperature compensation
- Electro-chemically polished surfaces
- Mounting attitude insensitivity
- Reduced dead volume
- Vibration insensitivity
- No seals
- Super stable patented heater-sensor

Ambient Temperature plus 1°C typical

- No flow
- With Flow

Ambient temperature

HEATER
The patented heater/sensor arrangement is of innovative design. The heater configuration is such that it always provides a thermally balanced zero.

MEASURING PRINCIPLE

THERMOPILE SENSOR
The sensor measures the temperature differences across the in- and outgoing legs of the measuring tube by means of a thermo pile. The thermo pile consists of thousands of thermo couples in series.

The inherent advantage of the use of the thermo pile is that at no flow the electronic zero signal is truly zero, and it does not drift.

With flow the large number of thermo couples generates a high and stable signal that can be easily amplified to 0-5(10)V or 0(4)-20 mA.

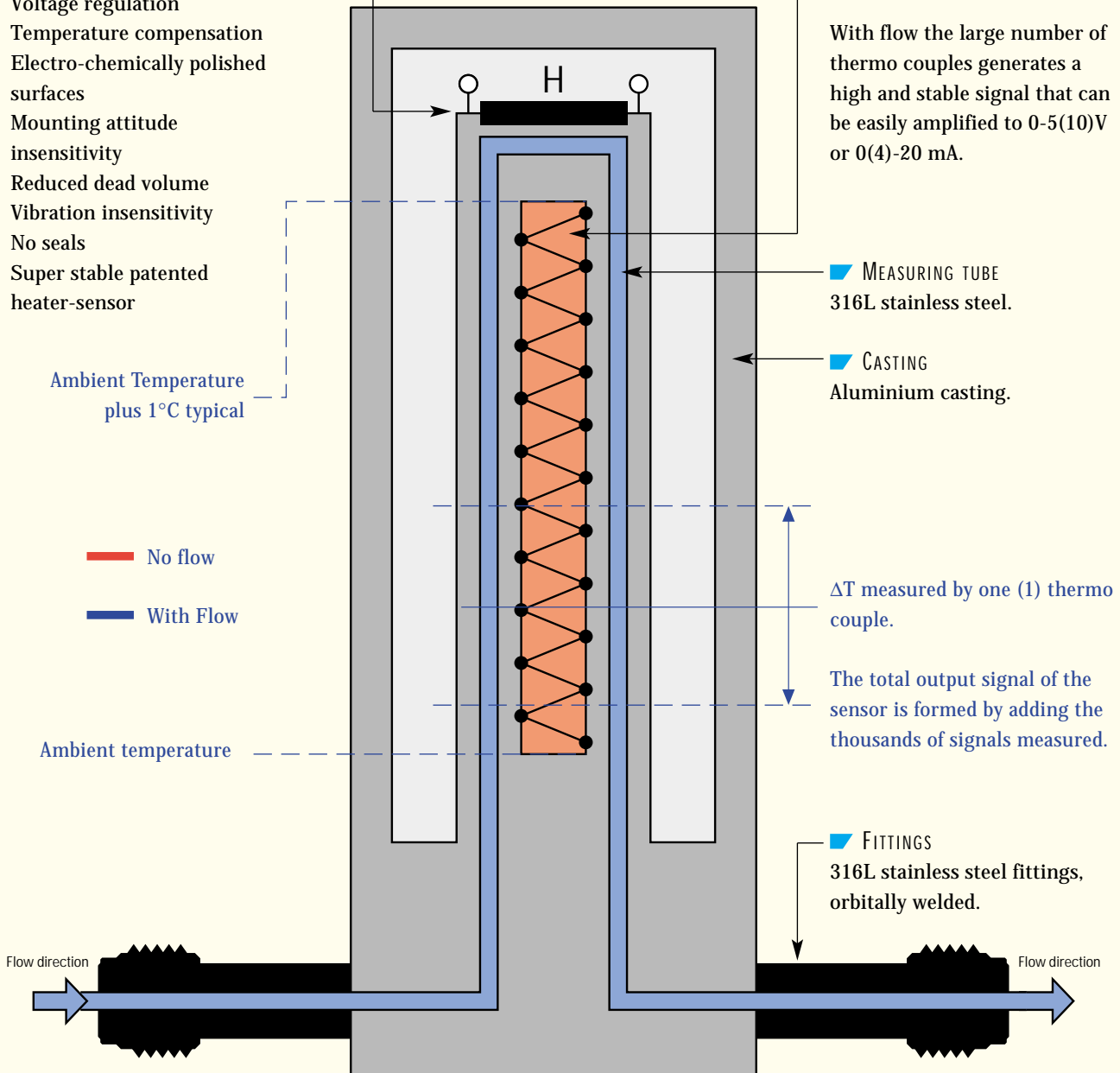
MEASURING TUBE
316L stainless steel.

CASTING
Aluminium casting.

ΔT measured by one (1) thermo couple.

The total output signal of the sensor is formed by adding the thousands of signals measured.

FITTINGS
316L stainless steel fittings, orbitally welded.



FUNCTIONAL MODULES

The LIQUI-FLOW® meter is available in 2 sizes, one up to approx. 100 g/h and another up to approx. 1000 g/h.

The meter body can be expanded with a number of other functions such as:

- Flow control
- Pressure measurement
- Positive shut-off
- Filtering

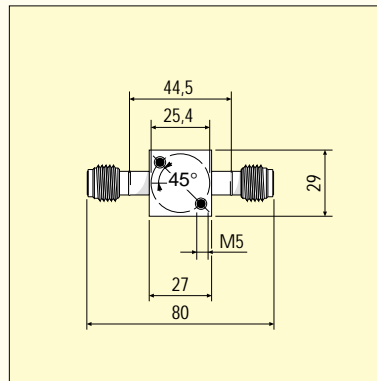
The functional modules are mounted on base-blocks. The base-blocks for the control valve-, the pressure transducer- and the filter modules are identical; for the shut-off valve it has a different internal cavity. There is only one (1) metal-to-metal seal of the well proven NUPRO® design, with excellent re-sealing capability.

Virtually any desired combination of the available functions can be made by orbitally welding or coupling together the required numbers and types of base-blocks. When mounted in the line, the base-blocks have become an integral part of the system which need not be removed in case of service.

FEATURES

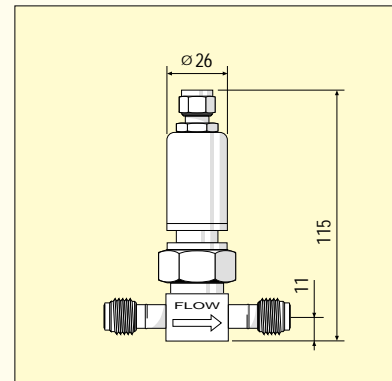
- Compact and flexible design
- One (1) metal seal
- Orbital welding
- Electro chemically polished
- Ultrasonically cleaned
- Cleanroom assembled and inspected
- Helium leak tested
- Service friendly

BASE-BLOCK OF FUNCTIONAL MODULE



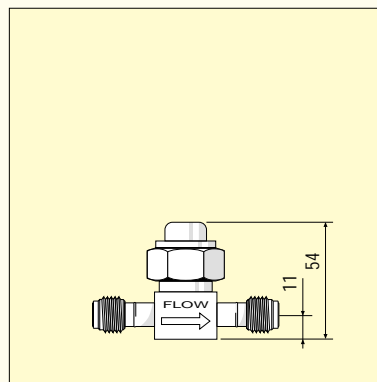
ALL DIMENSIONS IN MILLIMETRES

CONTROL VALVE (NC/NO)



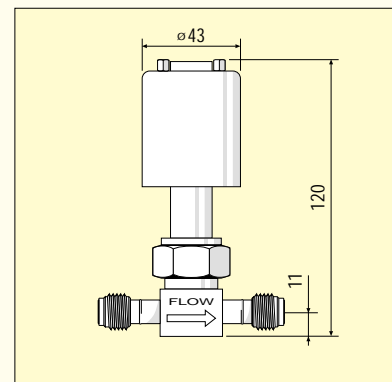
Normally closed or normally opened control valve for mass flow or pressure control with a max. K_v -value of $4,9 \times 10^{-2}$

SINTERED METAL 316L FILTER



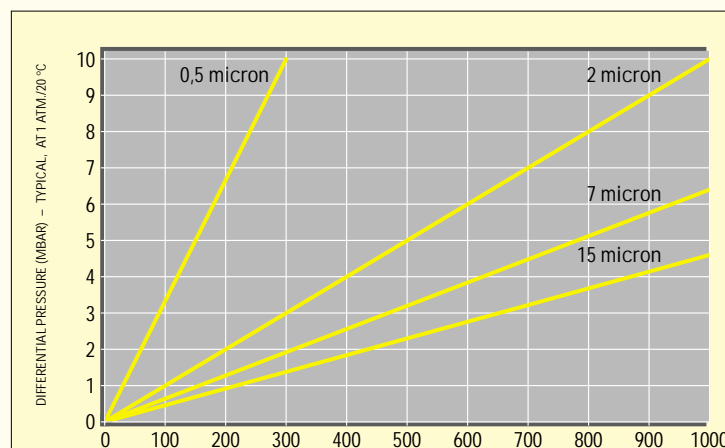
Porous sintered stainless steel filter in nominal pore sizes: 0,5-2-7-15 micron

PRESSURE TRANSDUCER

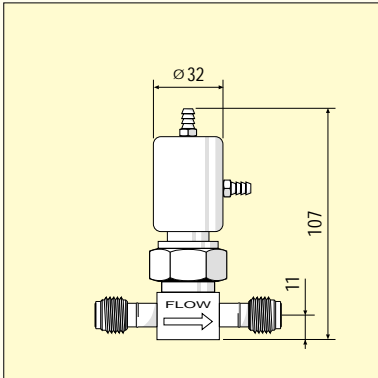


Piezo resistive pressure transducer with a stainless steel membrane. Ranges up to 100 bar.

DIFFERENTIAL PRESSURE OF SINTERED METAL FILTERS (BASED ON WATER)

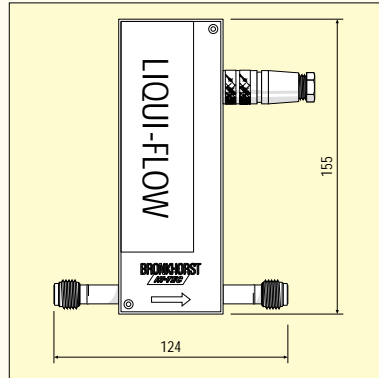


SHUT OFF VALVE (NUPRO, NC/NO)



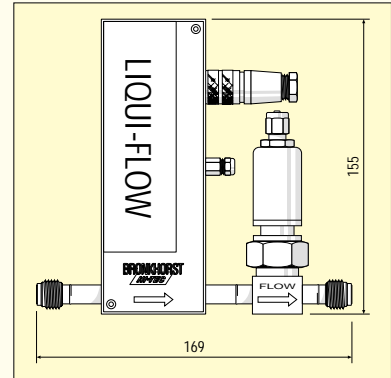
Normally closed or normally opened air actuated bellows shut-off valve (NUPRO).

LIQUI-FLOW® METER



Ranges up to 1000 g/h

LIQUI-FLOW® CONTROLLER



Ranges up to 1000 g/h

CHARACTERISTICS

STEM TIP:

Kel-F

FLOW COEFFICIENT

$K_v = 0,27$

INBOARD HE LEAKTIGHTNESS

4×10^{-9} mbar l/s

AIR ACTUATOR PRESSURE:

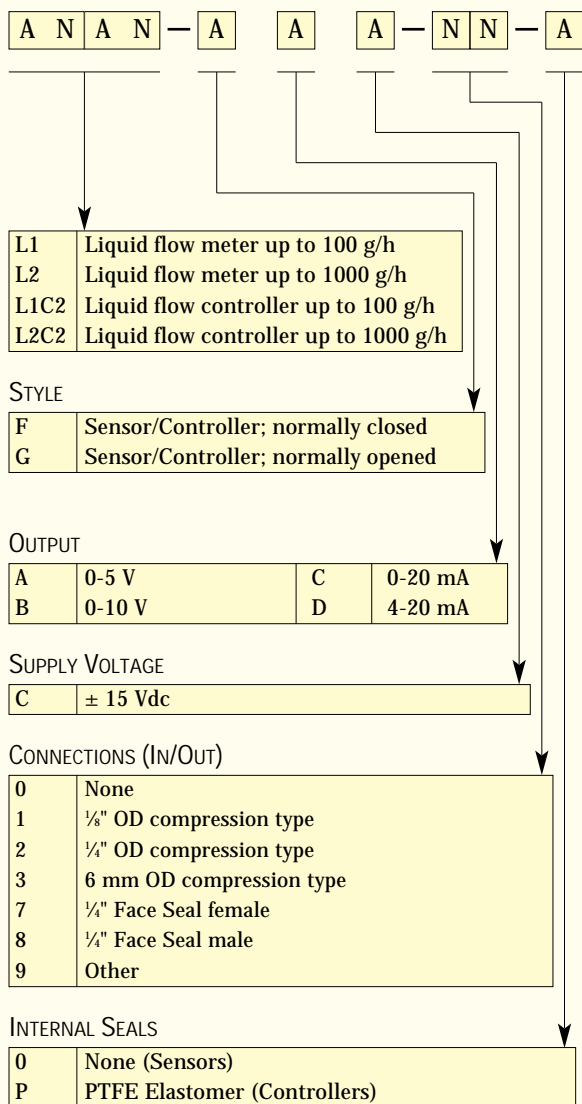
4 barg (NC)

3 barg (NO)



MODEL NUMBER IDENTIFICATION

LIQUI-FLOW® METERS/ CONTROLLERS



ADDITIONAL FUNCTIONAL MODULES

FUNCTION	
P5	Pressure sensor
S0	Shut-off valve, NC
S1	Shut-off valve, NO
M1	Sintered metal filter

The code for these modules can be integrated in the model number of the complete instrument, e.g.

M1L1 = Liquid flow meter up to 100 g/h
with sintered metal filter at the inlet.

L2C2S0 = Liquid flow controller up to 1000 g/h
with NC Shut-off valve at the outlet.

APPLICATIONS

PILOT PLANTS

Accurate, continuous flow measurement and control of small liquid flows to replace:

- metering pumps
- weighing methods

Catalyst flow control into reactor in petro chemical processes to optimize product quality

INDUSTRIAL

The control of small flows in various processes, such as:

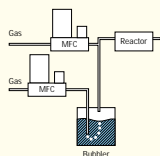
- odorizing paper towels , diapers etc.
- tobacco blending
- fermentation reagent control
- hollow fibre manufacture
- additive control in food
- additive control in petrol

CHEMICAL VAPOUR DEPOSITION

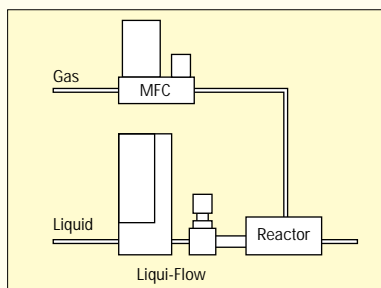
- The replacement of bubbler systems by liquid flow control into reactor
- Replacement of "Source Controllers"
- Replacement of high-temperature MFC's for gas i.e. change operating conditions to liquify the gas and install a LIQUI-FLOW® to work under normal temperature and pressure.

Bubbler system

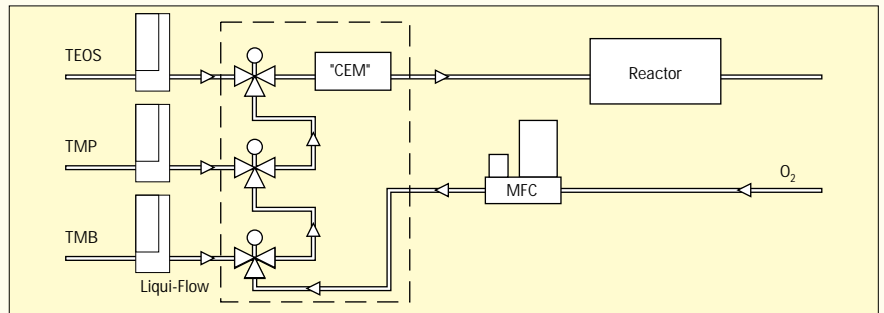
now replaced by



DIRECT LIQUID FLOW CONTROL INTO REACTOR



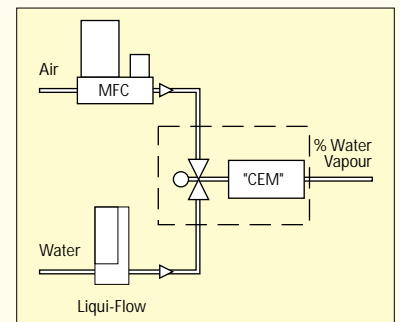
MONOMER CONTROL IN PLANARIZATION PROCESSES WITH SUBSEQUENT EVAPORATION



"CEM"-SYSTEM

Controlled Evaporation Mixing
A liquid/gas mass flow controlled mixing system with subsequent temperature controlled evaporation into atmospheric, pressurized or vacuum processes.

"CEM"-SYSTEM, CONTROLLED EVAPORATION MIXING



LABORATORY

Very low flow measurement and control to replace metering pumps, pipettes etc.

- The making of defined vapour concentrations in order to check analysers; for instance a defined water vapour concentration in air

QUALITY ASSURANCE

- Drip-control-pump calibration
- Leaktest control, for instance of ABS-brake system components
- Functional test of high pressure pumps for HPLC etc.

POWER SUPPLY / READOUT SYSTEMS

Bronkhorst High-Tech offers a wide range of readout systems for powering LIQUI-FLOW® meters and controllers. All models can also operate with EL-FLOW® gas mass flow meters/controllers and/or EL-PRESS pressure transducers / controllers. On this page we briefly describe our economical analog models as well as our sophisticated digital units, in single-, dual- or multi-channel executions.

ANALOG STANDARD PS/READOUT SYSTEMS; SERIES E-5700

For applications where the features of digital PS/Readouts are not yet required Bronkhorst High-Tech offers their Series E-5700 standardised types of analog Power Supply / Readout Systems.



E-5752 2-CHANNEL PS/READOUT

Features

- 1 indicator per two channels plus switch for channel selection.
- 1 setpoint potentiometer per channel.
- Switch for internal/external setpoint.
- 100...240 Vac supply voltage.

Housing

- 2-channel system in compact table top or panel mount model (96 x 144 cm)
- 4- and 6-channel systems in 1/2"19" table top or rack housing



E-7500 SINGLE CHANNEL MODULE

FLOW-BUS SINGLE CHANNEL MODULE

This power supply/readout unit combines intelligent electronics with great flexibility of application. The mechanical construction is similar to the analog model. The microprocessor-based electronics of the E-7000 series offers many advantages:

- 16-figure display in percent or direct reading
- Possibility to store up to 8 calibration curves for various fluids
- Storage of polynomial calibration function for improved accuracy
- Totalization or batchcounter functions
- Purge/shut-off modes, easy accessible

FLOW-BUS MULTI-CHANNEL VERSIONS

Based on the modular technique of the single channel modules, it is easy to assemble multi-channel executions. This way 3 channels fit into a 1/2"19" housing and 6 channels fit into a 1" housing, either for rack mount or table top. For most applications one power supply can serve three channels.

The modular style of the E-7000 FLOW-BUS series enables you to expand your system with additional channels or to hook it up to a process control system. All essential functions for the use of thermal mass flow

meters and controllers are supported:

- Conversion factor settings
- Internal/External setpoint mode
- Master/Slave control
- Host Control by PC/Fieldbus, by means of an RS-232 or Profibus-DP interface



E-7100 3-CHANNEL PS/READOUT

SPECIFICATIONS FLOW-BUS SERIES E-7000

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 1/2"19".
- Table top or rack housing (max. 6 channels) 3 HE 1".

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 instruments connections.
- Sub-D connector for analog I/O functions.
- RJ-45 connector for connection to FLOW-BUS (Bronkhorst Hi-Tec fieldbus system)
- Max. power consumption +15 Vdc 1,5 A, -15 Vdc 150 mA.

TECHNICAL SPECIFICATIONS LIQUI-FLOW®

PERFORMANCE

Accuracy Rating	Standard Calibration	± 1% FS at H ₂ O, including non-linearity and repeatability (for other liquids the non-linearity may exceed ± 1% FS, depending on the range required, and the properties of the liquid, which is determined by the sliding fluid conversion factor)
	Polynomial Calibration	± 1% of reading plus ± 0,2% FS (independent of liquid).
Settling time		1-2 seconds.
Attitude Sensitivity		negligible.
Vibration Sensitivity		Virtually insensitive.
Temperature Sensitivity		Off zero - 0,002% of FS/°C Off span - 0,1% of reading /°C
Power Supply Sensitivity		± 10% change in 15V -no effect.
Auto Shut off		Valve closes when setpoint drops below 1%.
Leak Integrity		Each unit is tested to meet 1×10^{-9} mbar.l.s. ⁻¹ He, additionally a pressure test at 1,5 times the max. stated operating pressure is performed.

MECHANICAL CHARACTERISTICS

Process Connections		Std: 1/4" Face Seal or 1/8", 1/4" or 6 mm OD compression type, orbitally welded to body.
Material of Construction	Wetted	Stainless steel 316L or equivalent high alloy ferretic stainless steel.
Outer Seal		None in meter; controller: only one metal-to-metal seal (in valve module) with excellent resealing capability.
Valve Seat	Plunger	Elastomeric PTFE, or other on request.
Weight		Meter L1 - 1,0 kg; Controller L1C2 1,4 kg. Meter L2 - 1,5 kg; Controller L2C2 1,9 kg.

ELECTRICAL CHARACTERISTICS

Power Supply		+ 15 Vdc, 450 mA max: 300 mA for controller L1C2 ; 450 mA for L2C2. 150 mA for meter L1 ; 250 mA for L2. - 15 Vdc, 35 mA typical.
Output Signal		0...5(10) Vdc linearly proportioned to mass flow; min. load impedance 2 k ohm at 5 V; short circuit protected.
Command Signal		0...5(10) Vdc min. input impedance 1 M ohm. 0...5/1...5 Vdc for mA output.
Reference Signal Output		5(10)Vdc min. load impedance 2 k ohm.
Valve Performance		Monitor valve voltage by connecting a voltmeter to pin 4 (common) and pin 5 (valve +).
Purge Mode		100% setpoint.
EMI/EFI Protection		Completely shielded electronics.
Electrical Connection		Male, Amphenol C091 31 C008 2002
Ingress protection		IP 65 (weatherproof) for meter; for controller on request.

OPERATING LIMITS

Flow Capacity	Based on H ₂ O	L1: 0,1... 5 g/h. 0,2... 10 g/h. 0,4... 20 g/h. 1... 50 g/h. 2...100 g/h.	L2: 2... 100 g/h. 4... 200 g/h. 10... 500 g/h. 20... 1000 g/h.	<i>Note:</i> <i>Higher or lower flow ranges available on application.</i> <i>Intermediate values also possible.</i>
Control Range	Turn Down	2 ... 100%.		
Liquids		Any clean liquid compatible with SS316, and at operating conditions below boiling point.		
Operating Temperature	Ambient range	0°C to + 70°C		
Maximum operating pressure	(meter only) (meter + integral valve)	400 bar. 100 bar; up to 400 bar on application		
Differential Pressure Range	(meter+integral valve)	up to 10 bar; higher on application depending on K _v -calculation.		
Pressure Drop	Based on H ₂ O	L1: max. 5 mbar. L2: max. 250 mbar.		
Mounting position		Any position.		
Warm-up time	After turning on power	30 min. for best accuracy. 3 min. for accuracy ± 2% FS.		

CALIBRATION

References		Verified by NKO, the Dutch calibration organisation, and traceable to Dutch and international standards.
System		Precision laboratory balances.
Liquids		Standard calibration liquid: H ₂ O. For other liquids apply to factory.
Fluid Data		We have accumulated a data bank (FLUIDAT) that enables us to accurately determine liquid properties, such as density, specific heat, heat conductivity and viscosity under the prevailing operating conditions; however, the file is not complete. Therefore please provide aforementioned properties, as they are necessary to accurately calculate the conversion factor.
Fluid conversion factor (C)		$C = C_{p1}/C_{p2} + \lambda$ correction; accuracy approx. 1%.

The general formula for determining the relationship between signal and mass flow reads:

$$V_{\text{signal}} = k_1 C_p \varnothing_m \left(1 + \frac{k_2 C_p \varnothing_m}{\lambda} + k_3 C_p \varnothing_m \right) \text{ in which:}$$

V_{signal}	=	output signal
k_1	=	meter constant = calibration constant
C_p	=	specific heat
\varnothing_m	=	mass flow = $\rho \cdot \varnothing_v$
ρ	=	density
\varnothing_v	=	volume flow
k_2	=	meter constant
λ	=	heat conductivity
k_3	=	meter constant

As soon as the C_p and/or λ of the liquid to be metered change(s) the signal must be corrected. The conversion factor C is determined as follows:

$$C = \frac{V_{\text{signal 1}}}{V_{\text{signal 2}}}$$

C	=	conversion factor
1	=	fluid for which was calibrated
2	=	new fluid to be metered

OTHER BRONKHORST HI-TEC INSTRUMENTS FOR LIQUIDS

In addition to the instruments of the LIQUI-FLOW® series L1 and L2 described in this catalogue we would like to identify some other series mass flow meters and controllers for liquids within our product range:



■ µ-FLOW SERIES L0

For ultra low flow ranges of liquids Bronkhorst High-Tech developed the µ-FLOW series for 12,5...250 mg/h up to 0,1...2 g/h water equivalent. These thermal mass flow meters can be close-coupled to a LIQUI-FLOW® control valve, as described in this brochure for pulsation-free control of the above mentioned flow ranges.

The latest design of the µ-FLOW liquid flow meter can be equipped with a digital pc-board and can be downscaled to 500 nanolitres per minute.



■ LIQUI-FLOW® SERIES L30

These thermal mass flow meters and controllers offer an extension of the maximum flow range to a maximum of 20 kg/h water equivalent. Thanks to a patented sensor with thin-film technique the L30 series can measure these higher flows without using a by-pass and still with a very low rise in temperature of the fluid.



■ EX-LIQUI-FLOW SERIES XL1 AND XL2

For application in hazardous areas the LIQUI-FLOW® models L1 and L2 described in this catalogue can be converted to ex-proof instruments by mounting them into a flameproof housing with CENELEC approval according to EEx de IIC T6.

The models XL1 and XL2 can be coupled to a control valve with classification EEx e II T4 or EEx ib IIC T6, depending on the type of coil specified.



■ CORI-FLOW SERIES M50

For liquid flow ranges up to 600 kg/h Bronkhorst High-Tech designed a new series mass flow metering instruments, offering high accuracy (up to $\pm 0,1$ % FS plus $\pm 0,2\%$ of Reading). CORI-FLOW utilises a patented, advanced Coriolis type mass flow sensor to achieve unsurpassed performance, even with changing operation conditions in pressure, temperature, density, conductivity and viscosity. CORI-FLOW is offered with or without integral control valve and analog and digital communication, RS-232 with Profibus-DP or Devicenet. The M50 series can also be applied for gases.

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

BRONKHORST

HI-TEC

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E.LIQ.1102.B