FLUKE®
Calibration

molbloc-S®

Sonic Nozzle Based molblocs for Gas Flow up to 5 000 slm

Technical Data

molbloc-S® is a high precision transfer standard intended for calibrating other transfer standards or process flow meters and controllers. molbloc-S is used with molbox1™ or molbox RFM™ terminals to extend the range of molbloc/molbox™ calibration systems and deliver superior accuracy at medium and high flows. Existing molbox1 terminals with version 4.0 embedded software or later and all molbox RFM terminals are user upgradable for use with molbloc-S.

molbloc-S ranges

The mass flow rate through molbloc-S is directly proportional to the upstream absolute pressure and independent of the downstream or differential pressure. molbloc-S flow ranges are defined by the molbloc's Pressure to Flow Conversion Ratio, KF. KF is expressed in units of sccm/kPa and defines the relationship between mass flow and the absolute upstream pressure delivered to the molbloc-S.

molbloc-S calibrations are performed over flow ranges corresponding to either 20 to 200 kPa (3 to 30 psia) or 50 to 500 kPa (7 to 70 psia) upstream pressure.

For flow measurements to be valid, the flow at the throat of the molbloc-S venturi nozzle must be critical, i.e. the gas speed is equal to the local speed of sound. Critical flow is achieved when a sufficiently low back pressure ratio, or BPR (molbloc-S downstream absolute pressure divided by upstream absolute pressure) is maintained. The upper limit of acceptable molbloc-S BPR values for critical flow varies between about 0.5 and 0.9 depending on the Reynolds number of the flow.

Since the mass flow through molbloc-S is proportional to the upstream absolute pressure, the flow range for molbloc-S in an application may be limited by the BPR limit. To maximize the range of a molbloc-S element, a vacuum pump can be connected downstream to reduce

Features

- Covers ranges up to 5 000 slm in N_2 and air
- Useable with existing molbox1 and molbox RFM mass flow terminals and COMPASS software
- Proven critical flow venturi (sonic) nozzle operating principle supported by gravimetric calibration
- Minimal sensitivity to contamination
- Measurement uncertainty: ± 0.2 % of reading with molbox1 ± 0.5 % of reading with molbox RFM
- Air and N_2 calibrations available, humid air density compensation supports use with ambient air
- Excellent rangeability using full molbox pressure range; 10:1 turndown with vacuum downstream; new 350 kPa full scale molbox1 available for low pressure operation
- Redundant absolute upstream pressure measurement using both molbox absolute pressure transducers reduces uncertainty and increases reliability
- Integral gas temperature conditioning and measurement
- Continuous, real-time reading, as with traditional molbloc-L laminar element
- Can be fully automated

Nominal molbloc-S flow rate at various upstream pressures

		molbloc-S mass flow rate [slm @ 0 °C (32 °F)] when molbloc-S upstream pressure is:[1,2]							
Designator	K_r (sccm/kPa)	20 kPa (3 psia)	50 kPa (7 psia)	100 kPa (15 psia)	Minimum without vacuum[3]	150 kPa (22 psia)	200 kPa (30 psia)	250 kPa (36 psia)	500 kPa (70 psia)
5E1-S	50	1	2.5	5	7.7	7.5	10	12.5	25
1E2-S	100	2	5	10	15	15	20	25	50
2E2-S	200	4	10	20	28	30	40	50	100
5E2-S	500	10	25	50	67	75	100	125	250
1E3-S	1 000	20	50	100	129	150	200	250	500
2E3-S	2 000	40	100	200	248	300	400	500	1 000
5E3-S	5 000	100	250	500	596	750	1 000	1 250	2 500
1E4-S	10 000	200	500	1 000	1 173	1 500	2 000	2 500	5 000

[1] Flow values in table are valid only when critical flow is established.
[2] When volumetrically based mass flow units with reference temperatures other than 0 °C are used, flow values will generally be higher; for example, the flow values for a given molbloc and upstream pressure are approximately 7 % higher when expressed in slm at 20 °C. Flow values at a given pressure may vary by up to ± 2 % due to flowpath machining tolerances.
[3] Minimum upstream pressure to achieve critical flow with atmospheric pressure (approximately 100 kPa) downstream of molbloc-S (no vacuum).

the downstream pressure while flowing. When the downstream pressure is kept sufficiently low, the upstream pressure, and thus the mass flow rate, can be adjusted all the way down to the minimum value for the molbloc's calibration type without being limited by the BPR. If molbloc-S will be used with atmospheric pressure downstream (no vacuum pump), then the molbloc can only be used over a range of upstream pressures starting at the maximum pressure for its calibration type down to a minimum pressure value at which the BPR becomes equal to the BPR limit at the current Reynolds number. molbox1 includes features to measure BPR, automatically alert the operator when the BPR is too high and prevent measurements when flow is not critical.

Applications

Depending upon the nature and the normal operating conditions of the device under test (DUT), molbloc-S may be used upstream or downstream of the DUT. Some typical molbloc-S application configurations are described below. System hardware and the position of the components are selected to accommodate the pressure requirements of the DUT and to maintain the required back pressure ratio on molbloc-S while the upstream absolute pressure varies over its flow range. The rangeability of a molbloc-S element in a specific application depends upon the molbloc's pressure calibration range, the molbox1 pressure range, the molbloc's downstream pressure and the pressure available upstream of the molbloc.

molbloc-S used downstream of DUT with atmospheric pressure or vacuum downstream of the molbloc-S

This setup has the advantages of:

- molbloc-S downstream pressure can be a vacuum giving maximum rangeability to the molbloc.
- With a constant regulated pressure into the DUT, the flow can be set using a valve between the DUT and the molbloc-S.
- The DUT can control the flow allowing MFCs to be tested in "control mode."

This setup is typically used for:

- Calibration and test of mass flow controllers (MFCs).
- DUTs that are operated with ambient air upstream.
- Calibration and test of high pressure DUTs.
- Comparison with low and high pressure molbloc-L.

The flow range that is achieved by each molbloc-S element depends upon whether the molbloc-S downstream pressure is vacuum or atmosphere and the maximum back pressure that can be tolerated on the DUT. For example:

- With vacuum downstream of molbloc-S, an SP calibration of molbloc-S and a molbox1-A700K, the molbloc-S can be used at upstream pressures from 50 to 500 kPa, allowing 10:1 rangeability. The maximum molbloc-S upstream pressure may be limited to less than 500 kPa by the pressure supply available, the DUT's backpressure limit and/or the DUT pressure drop.
- With atmosphere downstream of molbloc-S, an SP calibration of molbloc-S and a molbox1-A700K, the molbloc-S can be used at upstream pressures from approximately 150 kPa (atmospheric pressure divided by the BPR limit—see range table for actual minimum flows for each molbloc-S) to 500 kPa, allowing up to 4:1 rangeability. The maximum molbloc-S upstream pressure may be limited to less than 500 kPa by the pressure supply available, the DUT's backpressure limit and/or the DUT pressure drop.

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- With vacuum downstream of molbloc-S, an LP calibration of molbloc-S and a molbox1-A350K, the molbloc-S can be used at upstream pressures from 20 to 200 kPa, allowing 10:1 rangeability. The maximum molbloc-S upstream pressure may be limited to less than 200 kPa by the pressure supply available, the DUT's backpressure limit and/or the DUT pressure drop.

molbloc-S used upstream of DUT

This setup has the advantage of:

- The DUT downstream connection can be left directly open to atmosphere.
  Note: When the DUT is downstream of the molbloc-S, the DUT cannot control the flow. The flow must be controlled by adjusting the pressure or flow upstream of molbloc-S.

This setup is typically used for:

- Calibration and test of DUTs that must have atmosphere or vacuum downstream.
- Calibration and test of low pressure DUTs.
- Comparison with a downstream molbloc-L.

The flow range that is achieved by each molbloc-S element depends upon the backpressure placed on molbloc-S by the DUT, the pressure range of the molbox1 and the maximum pressure that can be supplied. For example:

- The molbloc-S is connected upstream of the DUT and can be used at upstream pressures from a maximum of 500 kPa down to approximately 1.5 times the backpressure applied to the molbloc-S by the DUT. For DUTs with very low differential pressure, this allows rangeability of up to 4:1 (See molbloc-S range table for the minimum flow for each molbloc-S when downstream pressure is atmospheric).

Specifications

Supported by any molbox1 and/or molbox RFM mass flow terminals. May require software upgrade.			
		molbox1™	**molbox RFM™**
Normal operating temperature range		15 °C to 35 °C (59 °F to 95 °F)	
Storage temperature range		-25 °C to 35 °C (-13 °F to 95 °F)	
Normal operating pressure range		20 kPa to 200 kPa absolute (3 psia to 30 psia) or 50 kPa to 500 kPa absolute (7 psia to 70 psia) upstream	
Overall flow range		1 slm to 5 000 slm	
Inlet connection		5E1-S and 1E2-S: 1/4 in VCR™ 2E2-S thru 2E3-S: 1/2 in VCR™ 5E3-S and 1E4-S: 1 in VCR™ or 1 in NPT	
Outlet connection		5E1-S thru 2E3-S: 16 mm (3/4 in) ISO-KF style vacuum flange 5E3-S, 1E4-S: 40 mm (1-1/2 in) ISO-KF style vacuum flange	
Gases supported		Nitrogen (N_2), dry air, humid air, other gases pending	
Flow measurement			
Range		Dependent upon molbloc size and pressure calibration range (see molbloc-S ranges table)	
Required back pressure ratio		0.4 to 0.9 depending on Reynolds number	
Calibration gases (dry air calibration is required for humid air operation. Other gases pending. Consult factory)	Standard	Dry air only	
	Optional	N_2 only, both dry air and N_2	
molbloc-S pressure calibration ranges	Standard	Standard pressure (SP): 50 kPaa to 500 kPaa	
	Optional	Low pressure (LP): 20 kPaa to 200 kPaa	
Resolution[1]		± 0.001 % of FS	± 0.01 % of reading
Linearity[1]		± 0.1 % of reading	± 0.25 % of reading
Repeatability[1]		± 0.05 % of reading	± 0.10 % of reading
Precision[1]		± 0.12 % of reading	± 0.30 % of reading
Predicted stability[1] (one year)		± 0.05 % of reading	± 0.2 % of reading
Measurement uncertainty (with SP molbloc-S: calibration)	A700K[2]	± 0.2 % of reading from 50 to 500 kPa	± 0.5 % of reading from 50 to 500 kPa
	A350K	± 0.2 % of reading from 50 to 200 kPa	
Measurement uncertainty (with LP molbloc-S: calibration)	A700K[2]	± 0.2 % of reading from 50 kPa to 200 kPa, ± 0.2 % of 50 kPa flow from 20 kPa to 50 kPa	± 0.5 % of reading from 50 kPa to 200 kPa, ± 0.5 % of 50 kPa flow from 20 kPa to 50 kPa
	A350K	± 0.2 % of reading from 20 kPa to 200 kPa	

[1] Over the range of the molbloc-S pressure calibration when LP calibration is used with molbox1-A350K or SP calibration is used with molbox1-A700K.
[2] molbox1 A700K is the standard molbox1 (S/N 300 or higher) with 700 kPa (100 psia) reference pressure transducers.

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Ordering information

Model
molbloc-S mass flow elements are ordered by size designation
5E1-S molbloc Mass Flow Element
1E2-S molbloc Mass Flow Element
2E2-S molbloc Mass Flow Element
5E2-S molbloc Mass Flow Element
1E3-S molbloc Mass Flow Element
2E3-S molbloc Mass Flow Element
5E3-S molbloc Mass Flow Element
1E4-S molbloc Mass Flow Element

Includes
molbloc-S flow element, shipping and storage case, soft, reusable VCR O-rings for molbloc upstream connection; ISO-KF style centering ring, clamp and overpressure ring for molbloc downstream connection; mounting instructions, calibration at standard pressure (SP) with air and accredited calibration report. Low pressure (LP) calibration or calibration in N_2 also available.

Options
Special N_2 Calibration, standard pressure (SP) replaces air
Special N_2 Calibration, low pressure (LP) replaces air
Special Air Calibration, low pressure (LP) replaces SP air
Special Gas Calibration, standard pressure (SP) adds additional gas
Special Gas Calibration, low pressure (LP) adds additional gas

Options (installed)
Regulator 1/4 in
Regulator 1/2 in
Metering valve low flow
Metering valve high flow

Accessories
molstic-S, supply only, 1/4 in
molstic-S, supply only, 1/2 in
molstic-S, single, 1/4 in
molstic-S, single, 1/2 in
molstic-S, dual, 1/4 in
molstic-S, dual, 1/2 in

Regulator kit, 1/4 in
Regulator kit, 1/2 in
PK-MOL-S-VAC, dwn vac connect
VA-MOL-S, vac pump kit, med std
VA-MOL-S, vac pump kit, med PFPE
VA-MOL-S, vac pump kit, low std

Tee assembly, for molbloc-S, downstream
Metering valve kit, molstic-S, 1/4 in, mid
Metering valve kit, molstic-S, 1/4 in, low
Filter kit, 5-micron, molstic-S, 1/2 in
DUT stand, adjustable
End flange kit, for molbloc-S, 1/4 in
End flange kit, for molbloc-S, 1/2 in

PK-MOL-KF16-1/4SWG, adaptor kit
PK-MOL-KF16-3/8SWG, adaptor kit
PK-MOL-KF16-1/4VCR, adaptor kit
PK-MOL-KF16-1/2VCR, adaptor kit
PK-MOL-KF16-1/4FNPT, adaptor kit
PK-MOL-KF16-1/4MNPT, adaptor kit
PK-MOL-KF16-1/2MNPT, adaptor kit

PK-MOL-KF25-1/4SWG, adaptor kit
PK-MOL-KF25-3/8SWG, adaptor kit
PK-MOL-KF25-1/2SWG, adaptor kit
PK-MOL-KF25-3/4SWG, adaptor kit
PK-MOL-KF25-1/4VCR, adaptor kit
PK-MOL-KF25-1/2VCR, adaptor kit
PK-MOL-KF25-1/4FNPT, adaptor kit
PK-MOL-KF25-1/2FNPT, adaptor kit
PK-MOL-KF25-3/4FNPT, adaptor kit
PK-MOL-KF25-1FNPT, adaptor kit
PK-MOL-KF25-1/4MNPT, adaptor kit
PK-MOL-KF25-1/2MNPT, adaptor kit
PK-MOL-KF25-3/4MNPT, adaptor kit
PK-MOL-KF25-1MNPT, adaptor kit

PK-MOL-KF40-1/2SWG, adaptor kit
PK-MOL-KF40-3/4SWG, adaptor kit
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europascal GmbH

An der Wiesenhecke 10
DE - 63456 Hanau
Tel.: +49 (0) 6181 / 42 309 – 0
Fax: +49 (0) 6181 / 42 309 – 22
Mail: service@europascal.de
www.europascal.de

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Fluke Calibration
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

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