FLUKE®

Calibration

molbox RFM™

Reference Flow Monitor

Technical Data

Features

- Compact presentation
- Covers the flow range of 1 sccm to 100 slm with molbloc-L, and up to 5000 slm with molbloc-S
- Select from 20 different gases with molbloc-L and 10 with molbloc-S
- Accredited measurement uncertainty of ± 0.5 % of reading with 100:1 rangeability
- Internal valving for on-board purge, leak test and tare support
- Includes advanced measurement functions such as totalize, average, hi/lo and deviation
- Complete front panel control and RS232 and IEEE-488 remote communications
- Measures mass and volume flow with user setable reference pressure and temperature conditions

molbox RFM is a support unit for making mass flow measurements using molbloc-L laminar and molbloc-S sonic flow elements.

molbloc flow elements are connected to molbox RFM with two pressure connections and one data line. molbox RFM reads calibration data off the molbloc EEPROM and measures molbloc upstream and downstream pressure with its built-in high accuracy Reference Pressure Transducers (RPTs). An ohmic measurement system reads the resistance of the molbloc platinum resistance thermometers from which molbloc temperature is calculated. Using the molbloc calibration data, pressures, temperature and gas properties stored in molbox RFM memory, the flow rate of the gas flowing through the molbloc is calculated. For molbloc-L flow elements, a microrange option is available to increase flow measurement resolution and accuracy under 10 % FS of the flow range.

molbox RFM and molbloc flow elements are useful in a variety of measurement, test and calibration applications in which highly accurate measurement of low gas flows where maximum accuracy is the most notable specification is needed. molbox RFM is specifically designed for applications in which a highly compact presentation, great rangeability and reduced cost are the primary considerations. A second model, molbox1, is available for applications in which lowest possible uncertainty is the top priority.

To configure your mass flow calibration system, see the pages that follow to select the molbloc and pressure dependent calibrations to best cover your flow ranges and pressure conditions. molstic mounting systems and COMPASS® for molbox calibration software are available to complete the system (see molstic and COMPASS product brochures).

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Flow measurement specifications

molbox RFM measures the flow through molbloc flow elements. The flow range, usable operating pressure, and differential pressure for molbloc-L, or the flow range and absolute pressure range for molbloc-S, depend on the molbloc element used and the calibration options. For molbloc-L ranges up to 3E4, the resolution and accuracy under 10 % FS are improved by the microrange option. For the 1E5-L molbloc, the microrange option is necessary to achieve the specification.

molbox RFM

	molbloc-L (ranges 1E1-L thru 3E4-L)	molbloc-S (all ranges)
Measurement update rate	1 second	1 second
Range	0 to molbloc full scale depending on gas and molbloc pressure dependent calibration type (see molbloc-L tables)	The flow related to 20 kPa to 200 kPa absolute (3 psia to 30 psia) or 50 kPa to 500 kPa absolute (7 psia to 70 psia) upstream (see molbloc-S table)
Resolution	0.01 % FS	± 0.01 % of reading
Linearity	± 0.23 % of reading from 10 % to 100 % FS, ± 0.023 % FS under 10 % FS	± 0.25 % of reading
Repeatability	± 0.1% of reading from 10 % to 100 % FS, ± 0.01% FS under 10 % FS	± 0.1 % of reading
Precision[1]	± 0.25 % of reading from 10 % to 100 % FS, ± 0.025 % FS under 10 % FS	± 0.3 % of reading
Predicted stability[2] (one year)	± 0.15 % of reading from 10% to 100% FS, ± 0.015 % FS under 10% FS	± 0.2 % of reading
Measurement uncertainty[3]	± 0.5 % of reading from 10% to 100% FS, ± 0.05 % FS under 10% FS	± 0.5 % of reading from 50 kPa to 500 kPa, ± 0.5 % of the flow @ 50 kPa from 20 kPa to 50 kPa

molbox RFM with Microrange option

	molbloc-L (ranges 1E1-L thru 3E4-L)	molbloc-L (ranges 1E5 only)
Measurement update rate	1 second	1 second
Range	0 to molbloc full scale depending on gas and molbloc pressure dependent calibration type (see molbloc-L tables)	0 to molbloc full scale depending on gas and molbloc pressure dependent calibration type (see molbloc-L tables)
Resolution	0.01 % FS, 0.001 % FS under 10 % FS	0.01 % FS
Linearity	± 0.23 % of reading from 1 % to 100 % FS, ± 0.0023 % FS under 1 % FS	± 0.25 % of reading from 5 % to 100 % FS, ± 0.0125 % FS under 5 % FS
Repeatability	± 0.1 % of reading from 1 % to 100 % FS, ± 0.001 % FS under 1 % FS	± 0.2 % of reading from 5 % to 100 % FS, ± 0.01 % FS under 5% FS
Precision[1]	± 0.25 % of reading from 1 % to 100 % FS, ± 0.0025 % FS under 1% FS	± 0.32 % of reading from 5 % to 100 % FS, ± 0.016 % FS under 5 % FS
Predicted stability[2] (one year)	± 0.15 % of reading from 1 % to 100 % FS, ± 0.0015 % FS under 1 % FS	± 0.2 % of reading from 5 % to 100 % FS, ± 0.01 % FS under 5 % FS
Measurement uncertainty[3]	± 0.5 % of reading from 1 % to 100 % FS, ± 0.005 % FS under 1 % FS	± 0.5 % of reading from 5 % to 100 % FS, ± 0.025 % FS under 5 % FS

[1] Precision: Combined linearity, hysteresis, repeatability.
[2] Predicted Stability: Maximum change in zero and span over one year for typical molbox RFM and molbloc used under typical conditions. As stability can only be predicted, stability for a specific molbox RFM should be established from experience.
[3] Measurement Uncertainty: Maximum deviation of the molbox RFM flow indication from the true value of the flow through the molbloc including precision, stability and DHI calibration standard uncertainty. Measurement uncertainty specifications for molblocs are valid only for gases with which the molbloc has been calibrated. All molblocs are calibrated for N2. Calibrations with other gases are optional. DHI calibration capability is not maintained at all times for all gases on all molbloc designations. Check for availability before ordering.

molbloc-S (all ranges)

Specifications are the same as a molbox RFM without Microrange. The Microrange transducer is disabled whenever the molbox RFM is connected to a molbloc-S.

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Pressure dependent calibration types for molbloc-S

The operating range of molbloc-S is dependent upon the absolute upstream pressure. Two different calibration options are offered to accommodate the requirement of the user's application. The Standard Pressure (SP) calibration of 50 kPa to 500 kPa absolute (7 psia to 70 psia) gives the most flexibility and allows partial use of the range without a vacuum. The Low Pressure (LP) calibration of 20 kPa to 200 kPa (3 psia to 30 psia) requires the use of a vacuum downstream. The resulting flow range for different gases at these pressures can be found in the molbloc-S range table below.

Calibration type	Operating pressure	Considerations
Standard pressure	50 kPa to 500 kPa absolute (7 psia to 70 psia)	Must be flowing to a vacuum to obtain full range
Low pressure	20 kPa to 200 kPa absolute (3 psia to 30 psia)	

molbloc-S ranges with standard and low pressure calibrations

					molbloc-S designator, KF (sccm/kPa), and full scale flow (slm @ 0°C)									
				Designotor	1E1-S	2E1-S	5E1-S	1E2-S	2E2-S	5E2-S	1E3-S	2E3-S	5E3-S	1E4-S
				KF (sccm/kPa)	10	20	50	100	200	500	1000	2000	5000	10000
	Gases		Ratio	Cal type										
Inert	Nitrogen	N2	1.000	SP	5.00	10.00	25.0	50.0	100.0	250.0	500	1000	2500	5000
				LP	2.00	4.00	10.0	20.0	40.0	100.0	200	400	1000	2000
				minimum	2.00	3.50	7.7	15.0	28.0	67.0	129	248	596	1173
	Argon	Ar	0.837	SP	4.19	8.37	20.9	41.9	83.7	209.3	419	837	2093	4186
				LP	1.67	3.35	8.4	16.7	33.5	83.7	167	335	837	1674
				minimum	1.67	3.00	6.9	13.9	24.3	61.0	122	245	526	1053
	Helium	He	2.647	SP	13.23	26.47	66.2	132.3	264.7	661.7	1323	2647	6617	13234
				LP	5.29	10.59	26.5	52.9	105.9	264.7	529	1059	2647	5294
				minimum	9.00	16.00	29.7	54.1	98.0	218.4	383	768	1928	3865
	Sulfur hexafluoride	SF6	0.435	SP	2.17	4.35	10.9	21.7	43.5	108.7	217	435	1087	2174
				LP	0.87	1.74	4.3	8.7	17.4	43.5	87	174	435	870
				minimum	0.63	1.10	2.7	5.5	10.9	23.4	47	94	235	471
	Xenon	Xe	0.460	SP	2.30	4.60	11.5	23.0	46.0	115.1	230	460	1151	2302
				LP	0.92	1.84	4.6	9.2	18.4	46.0	92	184	460	921
				minimum	0.80	1.50	3.3	6.7	13.4	33.7	58	116	290	580
Flammable	Ethane[1]	C2H6	0.996	SP	4.80	9.60	24.0	48.0	96.0	240.1	480	960	2401	4802
				LP	1.92	3.84	9.6	19.2	38.4	96.0	192	384	960	1921
				minimum	1.40	2.80	6.2	12.4	24.9	62.4	107	214	537	1074
	Ethylene[1]	C2H4	3.730	SP	4.98	9.96	24.9	49.8	99.6	248.9	498	996	2489	4979
				LP	1.99	3.98	10.0	19.9	39.8	99.6	199	398	996	1992
				minimum	1.70	3.00	6.5	13.1	26.2	65.8	113	226	565	1132
	Hydrogen	H2	1.320	SP	18.65	37.30	93.2	186.5	373.0	932.4	1865	3730	9324	18649
				LP	7.46	14.92	37.3	74.6	149.2	373.0	746	1492	3730	7460
				minimum	10.50	15.80	36.1	65.2	116.2	255.0	512	1026	2573	4415
	Methane	CH4	0.789	SP	6.60	13.20	33.0	66.0	132.0	330.0	660	1320	3300	6601
				LP	2.64	5.28	13.2	26.4	52.8	132.0	264	528	1320	2640
				minimum	2.64	4.50	10.0	17.6	35.3	88.6	178	304	763	1527
	Propane[1]	C3H8	0.563	SP	3.94	7.89	19.7	39.4	78.9	197.2	394	789	1972	3944
				LP	1.58	3.15	7.9	15.8	31.5	78.9	158	315	789	1577
				minimum	1.16	2.00	5.0	10.0	20.0	42.9	86	172	431	862
Fluoro-carbons	Carbon tetrafluoride[1]	CF4	0.447	SP	2.81	5.63	14.1	28.1	56.3	140.7	281	563	1407	2814
				LP	1.13	2.25	5.6	11.3	22.5	56.3	113	225	563	1126
				minimum	0.84	1.60	3.6	7.2	14.5	36.3	62	125	312	624
	Hexafluoroethene[1]	C2F6	0.629	SP	2.24	4.47	11.2	22.4	44.7	111.8	224	447	1118	2237
				LP	0.89	1.79	4.5	8.9	17.9	44.7	89	179	447	895
				minimum	0.65	1.10	2.8	5.6	11.2	24.1	48	96	241	483
	Trifluoromethane[1]	CHF3	0.983	SP	3.15	6.29	15.7	31.5	62.9	157.3	315	629	1573	3147
				LP	1.26	2.52	6.3	12.6	25.2	62.9	126	252	629	1259
				minimum	0.95	1.90	4.1	8.2	16.3	41.0	70	141	352	705
Other	Air	Air	0.795	SP	4.92	9.83	24.6	49.2	98.3	245.9	492	983	2459	4917
				LP	1.97	3.93	9.8	19.7	39.3	98.3	197	393	983	1967
				minimum	1.97	3.40	7.7	15.0	28.0	67.0	129	248	596	1173
	Carbon dioxide	CO2	1.000	SP	3.98	7.95	19.9	39.8	79.5	198.8	398	795	1988	3977
				LP	1.59	3.18	8.0	15.9	31.8	79.5	159	318	795	1591
				minimum	1.40	2.40	6.0	10.6	21.2	53.2	91	183	458	916
	Carbon monoxide	CO	0.795	SP	5.00	10.00	25.0	50.0	100.0	250.0	500	1000	2500	5000
				LP	2.00	4.00	10.0	20.0	40.0	100.0	200	400	1000	2000
				minimum	2.00	3.50	7.8	15.6	27.4	68.7	138	276	592	1186
	Nitrous oxide	N2O	0.367	SP	3.98	7.95	19.9	39.8	79.5	198.8	398	795	1988	3976
				LP	1.59	3.18	8.0	15.9	31.8	79.5	159	318	795	1590
				minimum	1.40	2.40	6.0	10.6	21.1	53.0	91	182	456	912
	Octafluorocyclobutane[1]	C4F8	0.935	SP2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
				LP	0.73	1.47	3.7	7.3	14.7	36.7	73	147	367	733
				minimum	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Oxygen	O2		SP	4.68	9.35	23.4	46.8	93.5	233.9	468	935	2339	4677
				LP	1.87	3.74	9.4	18.7	37.4	93.5	187	374	935	1871
				minimum	1.87	3.20	7.3	14.6	25.6	64.2	129	258	553	1107

Ratio = Inverse square root density ratio of the current gas to nitrogen
KF = Pressure to flow conversion ratio, sccm/kPa
To estimate a flow in a given gas at a given pressure: Flow(slm) = KF * pressure in kPa absolute/1000 * Gas Ratio

Cal types:
SP = Standard Pressure calibration 50 kPa to 500kPa absolute; table shows flow @ 500 kPa, flow @ 50 kPa is 10% of value shown.
LP = Low Pressure calibration 20 kPa to 200 kPa; table shows flow @ 200 kPa, flow @ 20 kPa is 10% of value shown.
minimum = table shows estimated minimum flow without vacuum if atmopheric pressure is ~ 100 kPa

Note: Non-Standard Pressure (NSP) calibrations are available up to 600 kPa absolute

[1] This gas is not currently supported by the molbox RFM
[2] The vapor pressure of octafluorocyclobutane is 230 kPa absolute, SP operation is not possible

All flows are nominal and approximate; in gases other than N2 and Air, flows may vary up to 10 % due to differences in characteristics and manufacturing

FLUKE®
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Pressure dependent calibration types for molbloc-L

Different pressure dependent calibration options for molbloc-Ls determine the range of operating pressures over which a molbloc-L can be used within its mass flow measurement specifications. The calibration option also affects the molbloc-L flow range and the differential pressure associated with the flow range. The different calibration options are offered to accomodate the requirement of the user's application. All molbloc-Ls are delivered with an N2 calibration (full mod, low pressure) by default. Calibrations with other gases or N2 calibration other than full mod, low pressure, must be specified.

Calibration type	Operating pressure	Nominal differential pressure at FS flow
Full mod, low pressure	250 kPa to 325 kPa absolute (22 psig to 33 psig) upstream of molbloc	0 kPa to 50 kPa (7.5 psi)
Full mod, high pressure	325 kPa to 525 kPa absolute (33 psig to 62 psig) upstream of molbloc	0 kPa to 50 kPa (7.5 psi)
Full mod, downstream	Atmospheric pressure downstream of molbloc	0 kPa to 100 kPa (15 psi)
Single P, low pressure (non-N_2 gases only)	Any specified single molbloc upstream pressure between 250 kPa and 325 kPa absolute (22 psig to 33 psig)	0 kPa to 50 kPa (7.5 psi)
Single P, high pressure (non-N_2 gases only)	Any specified single molbloc upstream pressure between 325 kPa and 525 kPa absolute (33 psig to 62 psig)	0 kPa to 50 kPa (7.5 psi)

molbloc-L ranges with low pressure calibrations

			molbloc-L size and full scale flow (sccm @ 0 °C)									
			Size									
	Gases		1E1	5E1	1E2	2E2	5E2	1E3	5E3	1E4	3E4	1E5
Inert	Nitrogen	N_2	10	50	100	200	500	1000	5000	10000	30000	100000
	Argon	Ar	10	50	100	200	500	1000	5000	10000	30000	80000
	Helium	He	10	50	100	200	500	1000	5000	10000	30000	100000
	Sulfur hexafluoride	SF_6	10	50	100	200	500	1000	2000 500	6000 1000	6000 4000	–
	Xenon	Xe	10	40	80	150	400	800	3500 500	8000	11000 3000	30000 20000
Flammable	Butane	C_4H_{10}	20	100	130 30	270 50	670 140	2300	2200 1400	7000 3000	– –	–
	Ethane	C_2H_6	20	100	200	400	1000	2000	6000 1000	18000 2000	18000 6000	60000 50000
	Ethylene	C_2H_4	16	18	160	320	800	1600	7000 1000	16000	20000 5000	70000 40000
	Hydrogen	H_2	20	100	200	400	1000	2000	10000	20000	60000	200000
	Methane	CH_4	16	80	160	320	800	1600	8000	16000	40000 5000	120000 40000
	Propane	C_3H_8	20	100	200	400	1000	2000	3000 1000	10000 2000	10000 7000	–
Fluoro-carbons	Carbon tetrafluoride	CF_4	10	50	100	200	500	1000	4000 600	10000	12000 3000	36000 25000
	Hexafluoroethene	C_2F_6	10	50	100	200	500	1000	2000 600	6000 1200	6000 4000	–
	Trifluoromethane	CHF_3	10	50	100	200	500	1000	4000 600	10000	12000 4000	38000 30000
Other	Air	Air	10	50	100	200	500	1000	5000	10000	30000	100000
	Carbon dioxide	CO_2	10	50	100	200	500	1000	5000	10000	20000 4000	60000 30000
	Carbon monoxide	CO	10	50	100	200	500	1000	5000	10000	30000	100000
	Nitrous oxide	N_2O	10	50	100	200	500	1000	5000	10000	20000 4000	60000 30000
	Octafluorocyclobutane[1]	C_4F_8	15	60 9	65 17	130 34	330 85	1100 175	1050 840	3400 1700	– –	–
	Oxygen	O_2	10	50	100	200	500	1000	5000	10000	30000	80000

See page 5 for footnotes.

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molbloc-L ranges with high pressure calibrations

	Gases		molbloc-L size and full scale flow (sccm @ 0 °C) Size 1E1	5E1	1E2	2E2	5E2	1E3	5E3	1E4	3E4	1E5
Inert	Nitrogen	N_2	20	100	200	400	1000	2000	10000	20000	40000 7500	N/A
	Argon	Ar	20	100	200	400	1000	2000	10000	17000	35000 6000	N/A
	Helium	He	20	100	200	400	1000	2000	10000	20000	65000	N/A
	Sulfur hexafluoride	SF_6	25	100 15	120 30	250 50	600 150	2000 300	2000 1400	6200 2800	– –	N/A N/A
	Xenon	Xe	20	100	150	350	650	1700	3350 950	11000 1900	11000 5700	N/A
Flammable	Butane[2]	C_4H_{10}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ethane	C_2H_6	40	200	350 50	700 100	1800 200	4000	6000 2300	20000 4500	20000 13800	N/A N/A
	Ethylene	C_2H_4	40	200	350	700	1800	4000	7000 2000	22000 4000	22000 12700	N/A
	Hydrogen	H_2	40	200	400	900	2000	4500	22000	45000	130000	N/A
	Methane	CH_4	35	175	350	700	1700	3500	13000 2000	33000	42000 12000	N/A
	Propane	C_3H_8	50	200 25	200 50	400 100	1000 250	3500 500	3500 2600	11000 5400	– –	N/A
Fluoro-carbons	Carbon tetrafluoride	CF_4	20	100	200	400	1000	2000	3700 1200	12000 2400	12000 7300	N/A
	Hexafluoroethene	C_2F_6	25	100 15	120 30	250 50	600 150	2000 300	1800 1500	6000 3000	– –	N/A
	Trifluoromethane	CHF_3	25	125	240 30	450 60	1200 150	2500	4000 1500	12000 3000	12000 8800	N/A
Other	Air	Air	20	100	200	400	1000	2000	10000	20000	40000 7200	N/A
	Carbon dioxide	CO_2	25	125	250	500	1250	2500	6600 1400	20000 2500	40000 8800	N/A
	Carbon monoxide	CO	20	100	200	400	1000	2000	10000	20000	40000 7500	N/A
	Nitrous oxide	N_2O	25	125	250	500	1250	2500	11000 1500	20000 3000	20000 9000	N/A
	Octafluorocyclobutane[2]	C_4F_8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oxygen	O_2	20	100	200	400	1000	2000	10000	20000	40000 6500	N/A

A bold value indicates that the maximum flow is limited by the maximum Reynolds number value of 1200 which is reached before the normal differential pressure range is reached. In that case, the second value gives the minimum flow for which measurement uncertainty (accuracy) is equal to the nominal uncertainty specification. Divide the second value by 10 when using molbox RFM microrange option.

Where there is no value in the field (–), this indicates that the maximum Reynolds number is reached before the differential pressure reaches 5 kPa (1 kPa in the case of the 1E5 molbloc), therefore calibration with that gas is not useful.

[1] Due to low vapor pressure, only downstream calibration type is available.
[2] The operating pressure range is greater than the vapor pressure value for this gas.

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General specifications

Power requirements		85 V ac to 264 V ac, 47 Hz to 440 Hz, 18 VA max consumption
Operating temperature range		15 °C to 35 °C (59 °F to 95 °F)
Storage temperature range		–20 °C to 70 °C (–4 °F to 158 °F)
Vibration		Meets MIL–T–28800D
Weight		2.55 kg (5.6 lb) max
Dimensions (H x W x D)		8 cm x 22.5 cm x 20 cm (3.1 in x 8.9 in x 7.9 in) approx.
Microprocessor		Motorola 68302, 16 MHz
Communication ports		RS–232 (COM1), RS–232 (COM2), IEEE–488
Reference pressure transducers (RPTs)	Standard	2 x 600 kPa (87 psia) piezoresistive silicon
	Microrange Option	12.5 kPa (1.8 psid) piezoresistive silicon
Gases supported	for molbloc–L	Nitrogen (N2), Air, Argon (Ar), Carbon Monoxide (CO), Helium (He), Oxygen (O2), Carbon Dioxide (CO2), Carbon Tetrafluoride (CF4), Ethane (C2H6), Ethylene (C2H4), Fluoroform (CHF3), Hexafluoroethane (C2F6), Hydrogen (H2), Methane (CH4), Nitrous Oxide (N2O), Propane (C3H8), Sulfur Hexafluoride (SF6)
	for molbloc–S	N2, He, Ar, H2, O2, CH4, Air, N2O, SF6, CO2, CO
Pressure connections		Quick connectors equivalent to Swagelok QM Series (–QM2–B200)
Pressure limits		Maximum working pressure: 600 kPa absolute (87 psia)
Flow ranges		Covers the flow range of 1 sccm to
		100 slm with molbloc–L, and up to 5000 slm with molbloc–S
Flow measurement uncertainty		± 0.5 % of reading
CE conformance		Available. Must be specified

Ordering information

Model
molbox RFM Reference flow monitor

Includes
Users manual, calibration certificate, power cord, (2) molbox RFM to molbloc pressure lines, (1) molbox RFM to molbloc data line, (2) Straight through pressure quick connectors

Options
RFM 02 Microrange

Accessories
RFM–RMK (401465) Rack mount kit
mfc–CB Analog MFC interface system (see mfc–CB brochure)
molstic molbloc mounting systems (see molstic brochure)
COMPASS® for molbox for Windows (401211) Calibration software

Fluke. *Keeping your world up and running.®*

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