



Euramet project 1072

Bilateral comparison

“Draft B”

Between the “Water flow measurement standards” of the National Metrology Institutes (NMI’s) of Bulgaria (BIM-NCM) and The Netherlands (VSL)

VSL

Hugo de Grootplein 1
3314 EG Dordrecht
Postbus 654
2600 AR Delft
The Netherlands

T + 31 15 269 15 00

F + 31 15 261 29 71

E info@vsl.nl

I www.vsl.nl

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Introduction and purpose of the bilateral comparison

The purpose of this bilateral comparison of water flow measurement standards is to support the Calibration and Measurement Capabilities (CMC) of the Bulgarian Institute of Metrology (BIM-NCM). This comparison has been performed under the framework of Euramet (known as project number 1072). The aim of the comparison was that the measurement errors at different flow-rates between the two water flow measurement standards found using two flow meters did not exceed the summed CMC claims of the two water flow measurement standards according to the E_n value calculation for bilateral comparisons ($E_n < 1$). VSL was the pilot laboratory for the bilateral comparison due to the fact that VSL has an entry in the International Bureau of Weights and Measures (BIPM) Mutual Recognition Arrangement (known as the CIPM MRA) for water flow measurement. For this bilateral comparison VSL has used Euramet Guide no. 3 "Euramet Guidelines on Conducting Comparisons". In addition VSL has followed the technical aspects of ILAC guideline G13 "ILAC Guidelines for the Requirements for the Competence of Providers of Proficiency Testing Schemes"

Dordrecht 21 July 2009,
Erik Smits
Liquid Flow and Volume Metrology



Micro Motion CMF200



Krohne Altometer Optiflux 5000

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1 The reference values

To compare the two water flow measurement standards two well known flow meters have been selected. The characteristics of these flow meters are described later in this document. For flow measurement standards it is impossible to have a direct reference value like a volume of a prover tank. Therefore the reference value is the measurement error of the quantity indication(s) (mass and or volume) of the flow meters at given flow-rates.

Reference value for a mass indicator of a flow meter

$$E_M = \frac{M_{IND} - M_{REF}}{M_{REF}} * 100\%$$

E_M = The measurement error of the Mass indication of the flow meter (%)

M_{IND} = Indicated mass of the flow meter (kg)

M_{REF} = The reference mass passed through the flow meter (kg)

The reference mass and Indicated mass for each observation can be different based upon flow-rate, test time, calibration method etc.

The reference mass could be best described as “The mass of the flowing water passed through the flow meter during an observation”. For example if the gravimetric calibration model is used the mass indication of the balance does not directly correspond with the mass indication of the flow meter. The appropriate calculation model needs to be used to calculate the mass passed through the flow meter. These calculation models correct between a reference instrument (for example the balance) and the flow meter under test for temperature effects, pressure effects, buoyancy forces etc.

The indicated mass can be read from the display of the flow meter or if provided with a software tool on a computer. It could also be the counted pulses divided by a known and programmed k-factor (p/kg).

The measurement error of the Mass indication of the flow meter at a given flow rate between the two water flow measurement standards can be compared. Between two observations on one water flow measurement standards there can be differences at the same flow-rate this is due to the repeatability of both water flow measurement standards and the used flow meter. An average is calculated for the comparison including an uncertainty for the repeatability at each given flow rate.

Reference value for a volume indicator of a flow meter

$$E_V = \frac{V_{IND} - V_{REF}}{V_{REF}} * 100\%$$

E_V = The measurement error of the volume indication of the flow meter (%)

V_{IND} = Indicated volume of the flow meter (m³)

V_{REF} = The reference volume passed through the flow meter (m³)

The reference volume and Indicated volume for each observation can be different based upon flow-rate, test time, calibration method etc.

The reference volume could be best described as “The volume of the flowing water passed through the flow meter during an observation”. For example if the gravimetric calibration model is used the mass indication of the balance does not directly correspond with the volume indication of the flow meter. The appropriate calculation model needs to be used to calculate the volume passed through the flow meter. These calculation models correct between a reference instrument (for example the balance) and the flow meter under test for temperature effects, pressure effects, buoyancy forces, density etc.

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The indicated volume can be read from the display of the flow meter or if provided with a software tool on a computer. It could also be the counted pulses divided by a known and programmed k-factor (ρ/m^3 or ρ/L).

The measurement error of the volume indication of the flow meter at a given flow rate between the two water flow measurement standards can be compared. Between two observations on one water flow measurement standards there can be differences at the same flow-rate this is due to the repeatability of both water flow measurement standards and the used flow meter. An average is calculated for the comparison including an uncertainty for the repeatability at each given flow rate.

2 Bilateral Comparison Evaluation Points (BCEP)

To make this bilateral comparison a success decided was that for each flow meter used the most optimized flow rates were chosen to compare the two water flow measurement standards. Per flow meter 2 flow rates were chosen where 10 repeats were taken. At these selected flow rates it was expected that the repeatability of the flow meters would be very good (known from previous calibrations and test with these types a flow meters). The found average measurement errors can then be compared for both water flow measurement standards. These points are called the Bilateral Comparison Evaluation Points (BCEP).

3 Specification of water flow measurement standards

3.1 Specification of water flow measurement standards of BIM-NCM

This bilateral comparison has been set up to support the CMC claim of BIM-NCM therefore it was needed to select flow meters based upon the specification of the water flow measurement standards of BIM.

The specifications of the water flow facility of BIM are:

Flow range	Stand 1: 0.002 to 6.3 m ³ /h – t/h Stand 2: 6.3 to 40 m ³ /h – t/h
CMC	Stand 1: 0.028 % for volume, volume flow, mass and mass flow Stand 2: 0.056 % for volume, volume flow, mass and mass flow
Volume storage tank	2.75 m ³
Temperature range	Ambient
Pressure range	1 to 6x10 ⁵ Pa
Unit under test sections	Stand 1: 3 to 25 mm Stand 2: 15 to 50 mm
References	Weighing scales, 150 kg and 600 kg
Liquid	Portable water
Standing start finish method in use	Yes (weighing scale with transfer point)
Flying start finish method in use	No

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3.2 Specification of water flow measurement standards of VSL

To be sure that the specifications of the BIM-NCM water flow measurement standards match with VSL the specifications on the water flow measurement standards of VSL was written down.

The specifications of the water flow facility of VSL are:

Flow range	0.001 to 400 m ³ /h – t/h
CMC	0.02% for volume, volume flow, mass and mass flow
Volume storage tank	190 m ³
Temperature range	Ambient
Pressure range	1 to 5x10 ⁵ Pa
Unit under test sections	2 sections 1 from 25 to 250 mm and 1 from 3 to 25 mm
References	Weighing scales, 10 ton, 3.5 ton, 600 kg, 160 kg and 6.1 kg max. load
	Pipe prover compact type, volume 120 litre and max flow-rate 800 m ³ /h
	Master meters, 3 turbines (50, 100 and 150 mm), 2 PD (25 and 50 mm) and 1 Coriolis mass flow (25 mm)
	Prover tanks 2000, 1000, 100, 50, 20, 10, 5, 2, 1, 0.5 litre
Liquid	Portable water
Standing start finish method in use	Yes (weighing scales, prover tanks both with transfer points)
Flying start finish method in use	Yes (Pipe prover, master meters both using double timing)

It is clear that the specification of the water flow measurement standards of VSL match with the water flow measurement standards of BIM-NCM.

4 The flow meters

Based upon the specification of the water flow measurement standards mentioned above the bilateral comparison needed to be done using a Standing Start Finish (SSF) method. Knowing this specification two flow meter were selected. The first meter is an Electro Magnetic Flow meter (EMF) size 15 mm. This one was chosen as EMF meters have a good track record during comparison performed in the past. The flow meter is fitted with an inlet and outlet pipe that is fixed to the flow meter. To make sure the pipes are not disconnected during the comparison two seals are put through the bolts with VSL seal number NMI00001 and NMI00002. This meter is owned by VSL and has put in use as a master meter for comparisons of any type. The second meter is a Coriolis mass flow meter size 50 mm. This one was chosen because Coriolis mass flow meters have a good track record during comparisons and BIM-NCM also wanted to check the CMC for mass and mass flow. This meter is owned by Micro Motion Inc, 7070 Winchester Circle, Boulder, CO 80301, USA. VSL does not own a Coriolis mass flow meter size 50 mm therefore Micro Motion was asked to provide one. VSL has been granted access to the track record including all calibrations performed on this Coriolis mass flow meter. Due to a confidentiality agreement between Micro Motion and VSL these records are kept out of any report or document concerning this bilateral comparison.

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4.1 Flow meter 1 Krohne Altometer Optiflux 5000

Specifications

Principal	Electro Magnetic Flow
Make	Krohne Altometer
Model	Optiflux 5000
Serial number	A07 05239
Maximum flow-rate	5 m ³ /h
Minimum flow-rate	0.5 m ³ /h
GK value	1.8507
Maximum pressure	8 × 10 ⁵ Pa (due to flanges of the inlet and outlet pipes)
Temperature range	-40 to +65°C
Electronics model	IFC 300
Serial number	A07 05239
Flanges (inlet and outlet)	DN15 PN16 (DIN 2633)
Build in length package	291 mm

4.2 Flow meter 2 Micro Motion CMF200

Specifications

Principal	Coriolis mass flow
Make	Micro Motion (Emerson Process Management)
Model	CMF 200
Serial number	14078674
Core-processor model	800
Core-processor serial number	10036203
Transmitter model	2700
Transmitter serial number	3768101
Maximum flow-rate	87.1 t/h - m ³ /h (*design flow 43.6 t/h - m ³ /h)
Minimum flow-rate	4.36 t/h - m ³ /h
Flow Calibration Factor (FCF)	215.424.45
Maximum pressure	8 × 10 ⁵ Pa
Temperature range	-40 to +65°C
Electronics model	MVD 2700
Serial number	09002241
Flanges	ANSI 2" 300#
Build in length	576 mm

* The design flow is the flow-rate where the pressure drop over the mass flow meter is about 1×10⁵ Pa.

5 Test protocol

In order to calculate the correct E_n values a strict protocol needed to followed to show a good measurement error per flow rate.

5.1 Test protocol flow meter 1 Krohne Altometer Optiflux 5000

The following protocol was used for the Optiflux 5000

Installation and preliminary checks

- The EMF meter needs to be installed using correct inlet and outlet pipes.
- The electronics need to plug into 220-230V power supply a minimum of 4 hours before the test can start. Make sure that the measuring tube of the EMF meter is filled with water.
- De-air the installation by flowing at the maximum flow of 5 m³/h for at least 30 minutes.

Test runs and sequence

- 3 runs at 5.0 m³/h = 83.3 l/min
- 10 runs at 4.0 m³/h = 66.7 l/min (BCEP 1)
- 10 runs at 3.0 m³/h = 50.0 l/min (BCEP 2)
- 3 runs at 2.0 m³/h = 33.3 l/min
- 3 runs at 1.0 m³/h = 16.7 l/min
- 3 runs at 0.5 m³/h = 8.33 l/min

Data to be collected during a test run

- EMF meter total at start
- Balance reading at the start
- Flow-rate indicated by EMF meter
- Average inlet temperature
- Average inlet pressure
- Average outlet temperature (if possible)
- Average outlet pressure (if possible)
- EMF meter total at end
- Balance reading at the end
- Air conditions (pressure, temperature and relative humidity)

At the end of the test runs

For the EMF meter there is no specific thing to be checked at the end of the test runs.

5.2 Test protocol flow meter 2 CMF200

At BIM-NCM the Coriolis mass flow meter needed to be tested with the meter-case up due to the meter under test section. To compare the two water flow measurement standards VSL tested also with the meter-case up. To be sure there is no effect between meter-case down and meter-case up VSL performed some extra test to check if the Coriolis mass meter is not affected between these two build in methods.

The result of this test is not reported in this report as this information is strict confidential information. There were some very small differences in the mass flow but if this is the water flow facility of VSL or the flow meter or a combination can't be identified.

The following protocol was used for the CMF200

Installation and preliminary checks

- The Coriolis mass meter needs to be installed using correct inlet and outlet pipes.
- The electronics need to plug into 220-230V power supply a minimum of 4 hours before the test can start. Make sure that the measuring tube of the Coriolis mass meter is filled with water.
- De-air the installation by flowing at a flow of 40 m³/h – t/h for at least 20 minutes.

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- For 15 minutes the flow-rate needs to be set to $10.9 \text{ m}^3/\text{h} - \text{t/h}$. This to stabilize the Coriolis meter before the zero calibration.
- Block in the Coriolis mass flow meters for zero calibration. If possible keep pump running.
- Perform the zero calibration for a minimum of 3 times when the zero has no trend to one side + or – the last zero can be used for the zero check. If there is a trend to one side then keep on zeroing until trend has stopped. If the trend does not stop check pressure and temperature to make sure there is no leak or anything else with the meter under test section otherwise contact the pilot laboratory.
- Set zero cutoff to zero and flow direction to bidirectional. Start totalizing the mass for 6 minutes the total mass in this six minutes should not exceed $\pm 0.036288 \text{ kg/min}$ conform the specification of the Coriolis mass flow meter. If it exceeds the specification restart the procedure from point 4 (For 15 min....).
- When the Coriolis mass flow meter is within the zero specification the zero cut-off can be set back to the initial value and the flow direction to forward.
- Write down all data and provide this to the pilot laboratory

A small video will be provided by the pilot laboratory to show the zero procedure.

Test runs and sequence

- 3 runs at $40.0 \text{ m}^3/\text{h} - \text{t/h} = 666.7 \text{ l/min} - \text{kg/min}$
- 10 runs at $32.7 \text{ m}^3/\text{h} - \text{t/h} = 545.0 \text{ l/min} - \text{kg/min}$ (BCEP 3 and 5)
- 10 runs at $21.8 \text{ m}^3/\text{h} - \text{t/h} = 363.3 \text{ l/min} - \text{kg/min}$ (BCEP 4 and 6)
- 3 runs at $10.9 \text{ m}^3/\text{h} - \text{t/h} = 181.7 \text{ l/min} - \text{kg/min}$
- 3 runs at $4.36 \text{ m}^3/\text{h} - \text{t/h} = 72.7 \text{ l/min} - \text{kg/min}$

Data to be collected during a test run

- Coriolis mass meter total at start (volume and mass)
- Balance reading at the start
- Flow-rate indicated by Coriolis mass meter (volume flow-rate and mass flow-rate)
- Average inlet temperature
- Average inlet pressure
- Average outlet temperature (if possible)
- Average outlet pressure (if possible)
- Coriolis meter total at end
- Balance reading at the end
- Air conditions (pressure, temperature and relative humidity)

At the end of the test runs

- Repeat the 6 minutes test to check zero flow. If the Coriolis mass flow meter has exceeded its specification ask advice from the pilot laboratory.
- Write down all data and provide this to the pilot laboratory

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6 Summarized results flow meter 1 Optiflux 5000

6.1 Results Optiflux 5000 VSL1

Results from VSL (test date: 8 October 2008).

Flow-rate [L/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
500	-0,028	0,0051	--	3
1000	-0,016	0,0045	--	3
2000	-0,030	0,0101	--	3
3000	-0,031	0,0044	0,0131	10
4000	-0,031	0,0036	0,0109	10
5000	-0,015	0,0036	--	3

These tests will be seen as VSL1

6.2 Results Optiflux 5000 BIM-NCM

Results sent to VSL by BIM-NCM (test date: 13 February 2009).

flow-rate (dm ³ /h)	volume error mean values (%)	uncert. type A (%)	uncert. type B (%)	total uncert. (%)	number of runs	degree of freedom	expansion factor k	expanded uncert. (%)
500	-0.036	0.0057	0.0080	0.0098	5	34.1	2.08	0.0204
1000	-0.012	0.0046	0.0042	0.0062	5	13.1	2.21	0.0138
2000	-0.040	0.0075	0.0042	0.0085	5	6.9	2.44	0.0208
3000	-0.036	0.0031	0.0042	0.0052	10	72.4	2.04	0.0105
4000	-0.017	0.0041	0.0042	0.0059	10	36.6	2.07	0.0121
5000	-0.008	0.0079	0.0041	0.0089	5	6.5	2.47	0.0221

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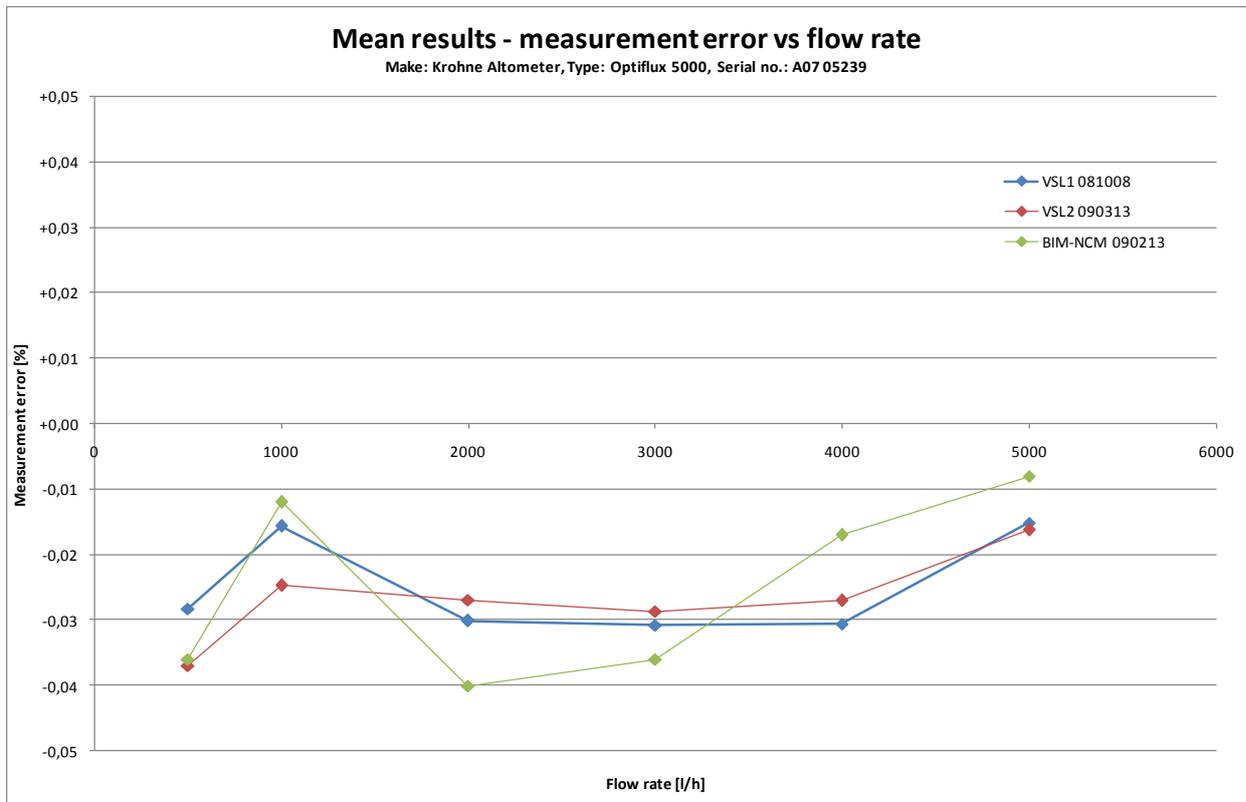
6.3 Results Optiflux 5000 VSL2

Results from VSL (test date: 13 March 2009).

Flow-rate [L/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
500	-0.037	0.0076	--	3
1000	-0.025	0.0015	--	3
2000	-0.027	0.0074	--	3
3000	-0.029	0.0022	0.0112	10
4000	-0.027	0.0039	0.0112	10
5000	-0.016	0.0013	--	3

These tests will be seen as VSL2

6.4 Results overview Optiflux 5000



7 Summarized results flow meter 2 CMF200

The found results are not corrected for the pressure effect of the meter. This effect is in flow according to the Product data sheet PS-00374, Rev. K of November 2008 of Micro Motion maximum -0.012% per bar. At VSL this effect was tested on the BCEP points and was found to be -0.006% per bar. As the pressure at BIM-NCM and VSL are measured at a different spots before the meter correction for differences in pressure is almost impossible. Therefore this effect should be added to the uncertainty calculation. For the volume flow rate there is also a pressure effect on the density this effect is 0.0145 kg/m³ per bar. Due to the fact that we are looking at the CMC claims and the difference in pressure are less than 1 bar this uncertainty source was not added to the calculation to keep the comparison as transparent as possible.

7.1 Results CMF200 Mass flow VSL1

Results from VSL (test date: 11 November 2008).

Flow-rate [kg/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
4360	+0.044	0.0054	--	3
10900	+0.032	0.0046	--	3
21800	+0.029	0.0024	0.0145	10
32700	+0.024	0.0019	0.0120	10
40000	+0.035	0.0023	--	3

These tests will be seen as VSL1

7.2 Results CMF200 Mass flow BIM-NCM

Results sent to VSL by BIM-NCM (test date: 11 and 12 February 2009).

flow-rate (kg/h)	mass error mean values (%)	uncert. type A (%)	uncert. type B (%)	total uncert. (%)	number of runs	degree of freedom	expansion factor k	expanded uncert. (%)
4360	0.054	0.0788	0.0040	0.0789	10	9.05	2.26	0.1779
10900	0.027	0.0295	0.0038	0.0298	10	9.30	2.19	0.0651
21800	0.041	0.0148	0.0037	0.0152	10	10.17	2.12	0.0322
32700	0.055	0.0108	0.0036	0.0114	10	11.11	2.09	0.0238
40000	0.060	0.0102	0.0036	0.0108	5	5.06	2.20	0.0238

After review of the results at the pilot lab it was found that the variance at a flow-rate of 4360 kg/h was large and not normal for the behavior of a coriolis meter at this flow rate. Then the data of the zero calibration was checked and it looked like the zero stability of the meter was not in order. The variance in the found zeros during its calibration was too large. An extra uncertainty sources was introduced for this effect.

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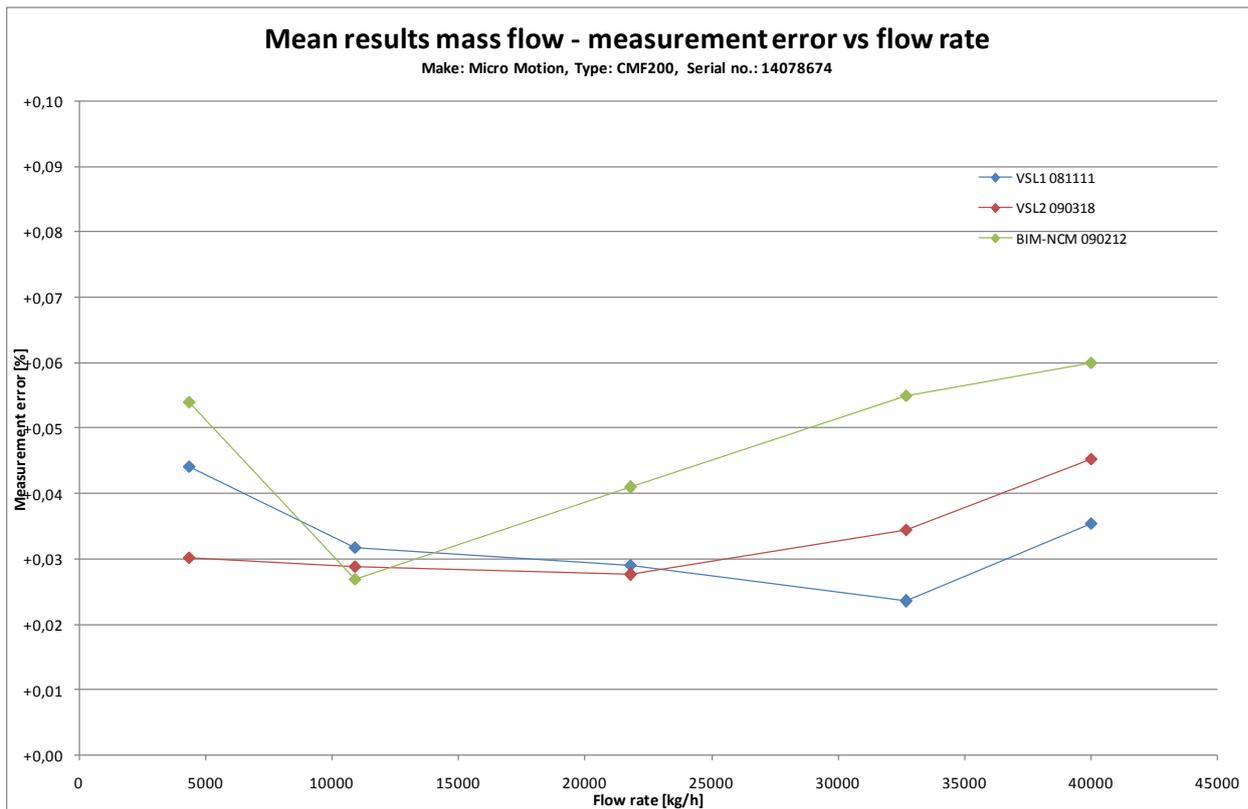
7.3 Results CMF200 Mass flow VSL2

Results from VSL (test date: 18 March 2009).

Flow-rate [kg/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
4360	+0.030	0.0007	--	3
10900	+0.029	0.0035	--	3
21800	+0.028	0.0013	0.0146	10
32700	+0.035	0.0016	0.0120	10
40000	+0.045	0.0025	--	3

These tests will be seen as VSL2

7.4 Results overview CMF200 Mass flow



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7.5 Results CMF200 Volume flow VSL1

Results from VSL (test date: 11 November 2008).

Flow-rate [L/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
4360	-0,021	0,0054	--	3
10900	-0,032	0,0045	--	3
21800	-0,029	0,0024	0,0149	10
32700	-0,029	0,0020	0,0125	10
40000	-0,015	0,0028	--	3

These tests will be seen as VSL1

7.6 Results CMF200 Volume flow BIM-NCM

Results sent to VSL by BIM-NCM (test date: 11 and 12 February 2009).

flow-rate (dm ³ /h)	volume error mean values (%)	uncert. type A (%)	uncert. type B (%)	total uncert. (%)	number of runs	degree of freedom	expansion factor k	expanded uncert. (%)
4360	-0.050	0.0788	0.0040	0.0788	10	9.05	2.32	0.1827
10900	-0.072	0.0298	0.0039	0.0298	10	9.30	2.21	0.0689
21800	-0.052	0.0152	0.0037	0.0152	10	10.17	2.28	0.0347
32700	-0.036	0.0114	0.0037	0.0114	10	11.10	2.25	0.0257
40000	-0.025	0.0107	0.0037	0.0107	5	5.07	2.64	0.0283

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7.7 Results CMF200 Volume flow VSL2

Results from VSL (test date: 18 March 2009).

Flow-rate [L/h]	Mean error [%]	U _A [%]	Expanded U [%]	n [--]
4360	-0.048	0.0005	--	3
10900	-0.047	0.0038	--	3
21800	-0.043	0.0014	0.0148	10
32700	-0.030	0.0016	0.0124	10
40000	-0.015	0.0022	--	3

These tests will be seen as VSL2

7.8 Results overview CMF200 Volume flow



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8 Calculation of the E_n values based upon CMC claims

To make this bilateral comparison a success the so called E_n value for comparison should be smaller than 1. For each BCEP point this calculation is made.

The formula for the E_n is:

$$E_n = \frac{X_{lab} - X_{pilot}}{\sqrt{CMC_{lab}^2 + CMC_{pilot}^2}}$$

The CMC claims of each lab can be found in paragraph specification of water flow measurement standards.

8.1 E_n values flow meter 1 Optiflux 5000 based upon CMC claims

The CMC claim for BIM-NCM = 0.028% and for VSL 0.02% for both BCEP 1 and 2.

Delta X

	Flow-rate [L/h]	BIM-NCM vs VSL1 [%]	BIM-NCM vs VSL2 [%]
BCEP 1	4000	+0.014	+0.010
BCEP 2	3000	-0.005	-0.007

E_n

	Flow-rate [L/h]	BIM-NCM vs VSL1 [--]	BIM-NCM vs VSL2 [--]
BCEP 1	4000	0.41	0.29
BCEP 2	3000	-0.15	-0.20

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8.2 E_n values flow meter 2 Mass flow CMF200 based upon CMC claims

The CMC claim for BIM-NCM = 0.056% and for VSL 0.02% for both BCEP 3 and 4.

Delta X

	Flow-rate [kg/h]	BIM-NCM vs VSL1 [%]	BIM-NCM vs VSL2 [%]
BCEP 3	32700	+0.031	+0.020
BCEP 4	21800	+0.012	+0.013

E_n

	Flow-rate [kg/h]	BIM-NCM vs VSL1 [-]	BIM-NCM vs VSL2 [-]
BCEP 3	32700	0.52	0.34
BCEP 4	21800	0.20	0.22

8.3 E_n values flow meter 2 Volume flow CMF200 based upon CMC claims

The CMC claim for BIM-NCM = 0.056% and for VSL 0.02% for both BCEP 5 and 6.

Delta X

	Flow-rate [L/h]	BIM-NCM vs VSL1 [%]	BIM-NCM vs VSL2 [%]
BCEP 5	32700	-0.007	-0.006
BCEP 6	21800	-0.023	-0.009

E_n

	Flow-rate [L/h]	BIM-NCM vs VSL1 [-]	BIM-NCM vs VSL2 [-]
BCEP 5	32700	-0.12	-0.10
BCEP 6	21800	-0.39	-0.15

9 Conclusion

The purpose of this bilateral comparison of water flow measurement standards was to support the Calibration and Measurement Capabilities (CMC) of the Bulgarian Institute of Metrology (BIM-NCM). As all E_n values are smaller than 1 we can say that the comparison was a success.

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10 Contact details of project members

Contact details for people involved in the bilateral comparison and role.

Coordinator Bilateral comparison and contact person VSL	Erik Smits VSL B.V. Hugo de Grootplein 1 3314 EG DORDRECHT The Netherlands T +31 78 6332201 (direct) E FSmits@vsl.nl	Responsible for organizing the bilateral comparison and execution of the test at VSL. Person in contact with and contact person for Euramet.
Project leader for comparisons between BIM-NCM and VSL	Jos Verbeek VSL B.V. Thijsseweg 11 2629 JA DELFT The Netherlands T +31 15 2691644 E JVerbeek@vsl.nl	Contact if there are any problems with any communications with coordinator.
Contact person BIM-NCM	Eugene Mitev Directorate of Measures and Measuring Instruments Bulgarian Institute of Metrology 52B, G.M.Dimitrov Blvd Sofia, 1040 Bulgaria e.mitev@mail.bg	Responsible for execution of the test at BIM-NCM.
Contact person Euramet	Richard Paton TUV NEL Scottish Enterprise Technology Park East Kilbride Glasgow G75 0QU Scotland E rpaton@tuvnel.com	Chairman Euramet technical committee Flow.

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11 Test data Optiflux 5000

11.1 Test data VSL 1 Optiflux 5000

Test date 8 October 2008

Air pressure: 1014 hPa

Air humidity: 55 %

Air temperature: 21°C

Flow-rate [L/h]	Reading [L]	T water [°C]	P water [bar(g)]	Net scale [kg]	Reference volume [L]	Error [%]
5000	211.360	18.90	2.12	210.94	211.40	-0.020
5000	210.990	18.92	2.12	210.55	211.01	-0.008
5000	210.936	18.93	2.12	210.51	210.97	-0.017
4000	141.147	19.03	2.19	140.84	141.15	-0.004
4000	141.337	19.03	2.19	141.07	141.38	-0.033
4000	141.349	19.04	2.19	141.09	141.40	-0.039
4000	141.308	19.05	2.19	141.04	141.35	-0.032
4000	141.289	19.06	2.19	141.03	141.34	-0.036
4000	141.421	19.08	2.19	141.15	141.46	-0.028
4000	141.312	19.09	2.19	141.06	141.37	-0.041
4000	141.275	19.11	2.19	141.02	141.34	-0.043
4000	141.382	19.12	2.19	141.10	141.41	-0.020
4000	141.298	19.13	2.19	141.03	141.34	-0.031
3000	115.628	19.18	2.25	115.39	115.65	-0.021
3000	117.713	19.19	2.25	117.49	117.76	-0.037
3000	114.823	19.20	2.25	114.60	114.86	-0.033
3000	115.425	19.21	2.25	115.21	115.47	-0.041
3000	115.612	19.22	2.25	115.35	115.61	0.003
3000	115.298	19.23	2.25	115.08	115.34	-0.034
3000	115.137	19.23	2.25	114.92	115.18	-0.039
3000	115.622	19.24	2.25	115.39	115.65	-0.023
3000	118.160	19.25	2.25	117.94	118.21	-0.042
3000	118.152	19.26	2.24	117.93	118.20	-0.040
2000	99.824	19.31	2.30	99.61	99.84	-0.016
2000	99.719	19.30	2.30	99.52	99.74	-0.025
2000	99.840	19.30	2.30	99.66	99.89	-0.050
1000	100.663	19.33	2.33	100.45	100.68	-0.018
1000	100.725	19.34	2.33	100.50	100.73	-0.007
1000	100.675	19.34	2.33	100.47	100.70	-0.022
500	89.114	19.38	2.34	88.95	89.15	-0.038
500	89.155	19.40	2.34	88.97	89.17	-0.020
500	89.184	19.42	2.34	89.01	89.21	-0.027

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11.2 Test data BIM-NCM Optiflux 5000

Test date 13 February 2009

Air pressure: 936 hPa

Air humidity: 36 %

run No	flow-rate (dm ³ /h)	water pressure (bar)	water temperature (°C)	air temperature (°C)	mass readings balance (kg)	volume readings meter (dm ³)	actual volume passed (dm ³)	volume error (%)
1	500	5.60	22.2	20.4	54.47	54.613	54.637	-0.043
2	500	5.60	22.1	20.4	51.75	51.884	51.912	-0.054
3	500	5.60	23.5	22.1	50.55	50.708	50.721	-0.026
4	500	5.60	23.4	22.0	53.87	54.037	54.050	-0.024
5	500	5.60	23.3	21.9	50.11	50.262	50.278	-0.032
6	1000	5.60	22.4	20.6	100.54	100.840	100.853	-0.013
7	1000	5.60	22.5	20.6	100.67	100.966	100.994	-0.028
8	1000	5.60	23.3	21.9	100.84	101.183	101.182	0.001
9	1000	5.60	23.0	21.9	100.87	101.188	101.202	-0.014
10	1000	5.60	23.0	21.9	100.92	101.246	101.254	-0.008
11	2000	5.60	23.0	20.8	101.00	101.283	101.332	-0.048
12	2000	5.60	22.5	21.4	100.78	101.077	101.097	-0.020
13	2000	5.60	22.5	21.2	100.79	101.079	101.106	-0.027
14	2000	5.60	22.6	21.8	102.15	102.411	102.473	-0.061
15	2000	5.60	23.0	20.8	100.09	100.374	100.419	-0.045
16	3000	5.40	22.6	21.8	101.03	101.332	101.358	-0.026
17	3000	5.50	23.0	20.9	101.42	101.736	101.755	-0.018
18	3000	5.50	23.0	20.9	101.39	101.669	101.724	-0.054
19	3000	5.50	23.0	20.9	100.87	101.166	101.201	-0.034
20	3000	5.50	23.0	20.9	101.26	101.551	101.591	-0.039
21	3000	5.50	23.2	20.9	101.34	101.640	101.676	-0.036
22	3000	5.50	23.2	21.1	100.38	100.674	100.711	-0.037
23	3000	5.50	23.3	21.1	100.83	101.137	101.171	-0.034
24	3000	5.50	23.4	21.3	100.51	100.815	100.855	-0.040
25	3000	5.50	23.4	21.1	100.55	100.847	100.892	-0.045
26	4000	5.20	22.6	22.3	101.18	101.506	101.507	-0.001
27	4000	5.20	22.6	22.3	101.31	101.629	101.636	-0.007
28	4000	5.20	22.6	22.3	101.28	101.592	101.600	-0.008
29	4000	5.20	22.6	22.3	101.77	102.053	102.093	-0.039
30	4000	5.30	21.6	21.6	101.08	101.352	101.384	-0.032
31	4000	5.30	21.7	21.6	101.36	101.642	101.665	-0.023
32	4000	5.30	23.4	21.5	100.43	100.755	100.773	-0.018
33	4000	5.30	23.4	21.6	101.37	101.688	101.714	-0.025
34	4000	5.30	23.4	21.9	101.54	101.862	101.882	-0.020
35	4000	5.30	23.7	21.9	100.80	101.154	101.154	0.000

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36	5000	5.20	22.6	22.1	101.65	101.985	101.978	0.007
37	5000	5.20	22.6	22.3	101.62	101.948	101.947	0.001
38	5000	5.20	22.6	22.1	101.56	101.891	101.890	0.001
39	5000	5.20	22.5	22.4	101.72	102.027	102.040	-0.013
40	5000	5.20	21.9	21.5	103.36	103.634	103.673	-0.037

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11.3 Test data VSL2 Optiflux 5000

Test date 13 March 2009

Air pressure: 1022 hPa

Air humidity: 44 %

Air temperature: 20.6 °C

Flow-rate [L/h]	Reading [L]	T water [°C]	P water [bar(g)]	Net scale [kg]	Reference Volume [L]	Error [%]
5000	175.732	17.47	1.83	175.42	175.76	-0.017
5000	175.595	17.48	1.83	175.29	175.63	-0.018
5000	175.628	17.50	1.83	175.31	175.65	-0.014
4000	140.948	17.53	1.91	140.71	140.98	-0.023
4000	140.644	17.55	1.90	140.40	140.67	-0.019
4000	140.693	17.58	1.90	140.50	140.77	-0.056
4000	140.748	17.59	1.90	140.52	140.79	-0.032
4000	141.216	17.61	1.91	140.95	141.23	-0.009
4000	140.997	17.62	1.90	140.76	141.04	-0.030
4000	140.596	17.64	1.90	140.35	140.63	-0.023
4000	140.581	17.65	1.90	140.35	140.62	-0.030
4000	140.888	17.66	1.91	140.65	140.93	-0.029
4000	140.638	17.68	1.90	140.39	140.66	-0.019
3000	104.966	17.73	1.96	104.78	104.99	-0.026
3000	105.544	17.73	1.96	105.36	105.57	-0.029
3000	105.054	17.74	1.95	104.87	105.08	-0.028
3000	104.642	17.75	1.95	104.45	104.66	-0.020
3000	105.414	17.76	1.95	105.23	105.44	-0.024
3000	105.382	17.77	1.96	105.20	105.41	-0.031
3000	105.408	17.78	1.95	105.22	105.43	-0.025
3000	105.599	17.78	1.96	105.42	105.64	-0.034
3000	105.770	17.79	1.95	105.58	105.80	-0.024
3000	105.483	17.81	1.96	105.32	105.53	-0.045
2000	69.838	17.84	2.00	69.72	69.86	-0.036
2000	69.916	17.86	2.00	69.80	69.94	-0.032
2000	69.980	17.87	2.01	69.85	69.99	-0.012
1000	56.495	17.91	2.03	56.39	56.51	-0.023
1000	56.493	17.94	2.03	56.39	56.51	-0.028
1000	56.676	17.95	2.04	56.57	56.69	-0.023
1000	59.195	17.97	2.04	59.10	59.22	-0.049
1000	59.291	18.01	2.05	59.18	59.30	-0.023
1000	59.202	18.03	2.04	59.10	59.22	-0.039

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12 Test data CMF200

12.1 Test data VSL1 CMF200

Test date 11 November 2009

Air pressure: 1006 hPa

Air humidity: 49 %

Air temperature: 21.5 °C

Flow-rate [kg/min]	Reading mass [kg]	Reading volume [L]	T water [°C]	P water [bar(g)]	Net scale [kg]	Reference mass [kg]	Reference volume [L]	Error mass [%]	Error volume [%]
666	1354,83	1355,56	18,53	2,77	1353,00	1354,40	1355,83	+0,031	-0,020
666	1362,62	1363,35	18,55	2,76	1360,70	1362,11	1363,55	+0,037	-0,015
664	1356,72	1357,49	18,55	2,76	1354,79	1356,20	1357,63	+0,038	-0,011
545	1108,57	1109,17	18,59	2,76	1107,09	1108,24	1109,42	+0,030	-0,022
546	1110,90	1111,50	18,58	2,76	1109,45	1110,60	1111,78	+0,027	-0,026
546	1119,23	1119,82	18,58	2,76	1117,75	1118,91	1120,10	+0,028	-0,025
545	1107,38	1107,96	18,58	2,76	1106,04	1107,19	1108,36	+0,017	-0,037
545	1112,68	1113,27	18,59	2,76	1111,33	1112,48	1113,66	+0,018	-0,035
545	1105,76	1106,36	18,64	2,76	1104,24	1105,39	1106,57	+0,033	-0,019
545	1116,88	1117,49	18,62	2,76	1115,50	1116,66	1117,85	+0,020	-0,032
545	1114,51	1115,12	18,62	2,76	1113,10	1114,26	1115,45	+0,023	-0,029
544	1108,36	1108,95	18,63	2,76	1107,04	1108,19	1109,37	+0,015	-0,038
545	1115,20	1115,81	18,63	2,75	1113,78	1114,94	1116,13	+0,024	-0,029
362	1100,83	1101,39	18,69	2,52	1099,23	1100,37	1101,57	+0,042	-0,017
363	1098,41	1098,97	18,66	2,52	1096,90	1098,04	1099,23	+0,034	-0,024
362	1154,06	1154,64	18,66	2,52	1152,50	1153,70	1154,95	+0,031	-0,027
361	1114,27	1114,83	18,66	2,52	1112,90	1114,06	1115,27	+0,019	-0,039
362	1101,30	1101,86	18,67	2,52	1099,85	1101,00	1102,20	+0,028	-0,030
361	1099,14	1099,69	18,68	2,52	1097,76	1098,90	1100,10	+0,021	-0,037
363	1130,18	1130,77	18,73	2,53	1128,59	1129,76	1131,01	+0,037	-0,021
362	1103,96	1104,52	18,70	2,52	1102,55	1103,70	1104,90	+0,024	-0,035
363	1104,47	1105,04	18,70	2,52	1102,95	1104,10	1105,30	+0,034	-0,024
362	1110,48	1111,06	18,70	2,52	1109,09	1110,24	1111,46	+0,022	-0,035
183	1100,18	1100,68	18,75	2,64	1098,59	1099,73	1100,94	+0,041	-0,023
182	1108,53	1109,05	18,74	2,64	1107,05	1108,20	1109,42	+0,030	-0,033
182	1105,07	1105,59	18,76	2,64	1103,65	1104,80	1106,01	+0,025	-0,039
73	1029,72	1030,18	18,81	2,76	1028,09	1029,16	1030,29	+0,055	-0,011
73	1031,12	1031,59	18,84	2,76	1029,65	1030,72	1031,87	+0,039	-0,027
73	1127,51	1128,02	18,86	2,76	1125,90	1127,07	1128,33	+0,039	-0,027

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12.2 Test data BIM-NCM CMF200

Test date 11 and 12 February 2009

Air pressure: 936 mbar

Air humidity: 40 %

Mass flow data

run No	flow-rate (kg/h)	water pressure (bar)	water temperature (°C)	air temperature (°C)	mass readings balance (kg)	mass readings meter (kg)	actual mass passed (kg)	mass error (%)
1	4360	5.50	20.3	22.6	400.78	401.609	401.221	0.097
2	4360	5.50	20.5	22.5	400.80	401.742	401.242	0.125
3	4360	5.50	22.6	21.8	401.32	402.592	401.763	0.206
4	4360	5.50	22.3	21.8	344.70	345.157	345.081	0.022
5	4360	5.50	22.3	21.6	401.70	401.964	402.144	-0.045
6	4360	5.50	22.2	21.5	401.04	401.072	401.484	-0.103
7	4360	5.50	22.4	22.4	402.10	402.602	402.543	0.015
8	4360	5.50	22.1	22.5	402.16	403.277	402.603	0.167
9	4360	5.50	22.0	22.8	300.94	301.016	301.271	-0.085
10	4360	5.50	21.8	22.5	299.78	300.544	300.110	0.144
11	10900	5.20	21.2	22.5	394.48	395.010	394.915	0.024
12	10900	5.20	21.2	22.6	397.30	398.000	397.738	0.066
13	10900	5.30	20.6	22.6	368.56	368.955	368.966	-0.003
14	10900	5.30	20.7	22.8	388.54	388.906	388.968	-0.016
15	10900	5.20	20.8	22.8	376.86	377.508	377.275	0.062
16	10900	5.20	20.9	22.9	379.78	380.218	380.198	0.005
17	10900	5.20	21.0	22.5	389.94	390.515	390.370	0.037
18	10900	5.20	21.0	22.4	402.06	402.585	402.503	0.020
19	10900	5.20	21.1	22.6	396.84	397.461	397.277	0.046
20	10900	5.20	21.1	22.5	392.58	393.115	393.013	0.026
21	21800	4.00	21.5	22.6	405.06	405.628	405.506	0.030
22	21800	4.00	21.6	22.6	399.84	400.491	400.280	0.053
23	21800	4.00	21.3	22.9	403.60	404.267	404.044	0.055
24	21800	4.00	21.3	22.9	404.16	404.798	404.605	0.048
25	21800	4.00	21.4	22.8	403.22	403.756	403.664	0.023
26	21800	4.00	21.4	22.8	411.52	412.177	411.973	0.050
27	21800	4.00	21.5	22.8	406.78	407.307	407.228	0.019
28	21800	4.00	21.5	22.6	403.22	403.869	403.664	0.051
29	21800	4.00	21.5	22.6	405.64	406.253	406.087	0.041
30	21800	4.00	21.5	22.6	404.08	404.682	404.525	0.039
31	32700	2.70	21.6	21.6	403.94	404.626	404.387	0.059
32	32700	2.70	21.6	21.6	409.40	410.118	409.853	0.065
33	32700	2.70	21.6	21.6	412.16	412.845	412.616	0.056
34	32700	2.70	21.5	21.6	412.12	412.834	412.576	0.063

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35	32700	2.70	21.5	21.6	407.54	408.220	407.991	0.056
36	32700	2.70	21.5	21.6	408.16	408.807	408.611	0.048
37	32700	2.70	21.5	21.6	408.16	408.863	408.611	0.062
38	32700	2.70	21.4	21.4	409.90	410.542	410.353	0.046
39	32700	2.70	21.3	21.4	407.68	408.356	408.131	0.055
40	32700	2.70	21.3	21.4	405.72	406.334	406.169	0.041
41	40000	2.20	22.3	21.6	400.36	400.975	400.803	0.043
42	40000	2.20	22.3	21.6	401.80	402.463	402.244	0.054
43	40000	2.20	22.3	21.6	416.34	417.109	416.800	0.074
44	40000	2.20	22.3	21.6	403.74	404.439	404.186	0.062
45	40000	2.20	22.3	21.8	405.06	405.782	405.508	0.068

Volume flow data

run No	flow-rate (dm ³ /h)	water pressure (bar)	water temperature (°C)	air temperature (°C)	mass readings balance (kg)	volume readings meter (dm ³)	actual volume passed (dm ³)	volume error (%)
1	4360	5.50	20.3	22.6	400.78	401.790	401.835	-0.011
2	4360	5.50	20.5	22.5	400.80	401.960	401.873	0.022
3	4360	5.50	22.6	21.8	401.32	402.998	402.585	0.103
4	4360	5.50	22.3	21.8	344.70	345.491	345.762	-0.078
5	4360	5.50	22.3	21.6	401.70	402.338	402.938	-0.149
6	4360	5.50	22.2	21.5	401.04	401.435	402.267	-0.207
7	4360	5.50	22.4	22.4	402.10	402.986	403.347	-0.090
8	4360	5.50	22.1	22.5	402.16	403.633	403.379	0.063
9	4360	5.50	22.0	22.8	300.94	301.275	301.845	-0.189
10	4360	5.50	21.8	22.5	299.78	300.788	300.668	0.040
11	10900	5.20	21.2	22.5	394.48	395.310	395.601	-0.074
12	10900	5.20	21.2	22.6	397.30	398.300	398.429	-0.032
13	10900	5.30	20.6	22.6	368.56	369.180	369.557	-0.102
14	10900	5.30	20.7	22.8	388.54	389.150	389.600	-0.115
15	10900	5.20	20.8	22.8	376.86	377.770	377.898	-0.034
16	10900	5.20	20.9	22.9	379.78	380.470	380.834	-0.096
17	10900	5.20	21.0	22.5	389.94	390.780	391.031	-0.064
18	10900	5.20	21.0	22.4	402.06	402.870	403.185	-0.078
19	10900	5.20	21.1	22.6	396.84	397.740	397.959	-0.055
20	10900	5.20	21.1	22.5	392.58	393.400	393.687	-0.073
21	21800	4.00	21.5	22.6	405.06	406.015	406.260	-0.060
22	21800	4.00	21.6	22.6	399.84	400.874	401.034	-0.040
23	21800	4.00	21.3	22.9	403.60	404.630	404.778	-0.036
24	21800	4.00	21.3	22.9	404.16	405.090	405.339	-0.061
25	21800	4.00	21.4	22.8	403.22	404.130	404.406	-0.068
26	21800	4.00	21.4	22.8	411.52	412.560	412.730	-0.041
27	21800	4.00	21.5	22.8	406.78	407.690	407.985	-0.072

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28	21800	4.00	21.5	22.6	403.22	404.250	404.415	-0.041
29	21800	4.00	21.5	22.6	405.64	406.640	406.842	-0.050
30	21800	4.00	21.5	22.6	404.08	405.067	405.278	-0.052
31	32700	2.70	21.6	21.6	403.94	405.045	405.172	-0.031
32	32700	2.70	21.6	21.6	409.40	410.545	410.649	-0.025
33	32700	2.70	21.6	21.6	412.16	413.280	413.417	-0.033
34	32700	2.70	21.5	21.6	412.12	413.251	413.368	-0.028
35	32700	2.70	21.5	21.6	407.54	408.636	408.774	-0.034
36	32700	2.70	21.5	21.6	408.16	409.216	409.396	-0.044
37	32700	2.70	21.5	21.6	408.16	409.268	409.396	-0.031
38	32700	2.70	21.4	21.4	409.90	410.946	411.132	-0.045
39	32700	2.70	21.3	21.4	407.68	408.755	408.896	-0.035
40	32700	2.70	21.3	21.4	405.72	406.722	406.930	-0.051
41	40000	2.20	22.3	21.6	400.36	401.488	401.654	-0.041
42	40000	2.20	22.3	21.6	401.80	402.970	403.099	-0.032
43	40000	2.20	22.3	21.6	416.34	417.643	417.686	-0.010
44	40000	2.20	22.3	21.6	403.74	404.955	405.045	-0.022
45	40000	2.20	22.3	21.8	405.06	406.284	406.369	-0.021

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12.3 Test data VSL2 CMF200

Flow-rate [kg/min]	Reading mass [kg]	Reading volume [L]	T water [°C]	P water [bar(g)]	Net scale [kg]	Reference mass [kg]	Reference volume [L]	Error mass [%]	Error volume [%]
660	1424,45	1424,82	17,25	1,95	1422,35	1423,87	1425,08	+0,041	-0,019
661	1426,31	1426,66	17,25	1,95	1424,09	1425,60	1426,82	+0,050	-0,011
661	1333,34	1333,67	17,27	1,94	1331,33	1332,74	1333,88	+0,045	-0,016
545	1113,80	1114,05	17,34	2,08	1112,14	1113,32	1114,28	+0,043	-0,021
545	1128,82	1129,06	17,29	2,07	1127,20	1128,40	1129,36	+0,038	-0,027
545	1116,77	1117,00	17,29	2,07	1115,20	1116,39	1117,34	+0,034	-0,030
545	1111,99	1112,22	17,29	2,08	1110,54	1111,72	1112,67	+0,025	-0,040
544	1114,76	1115,00	17,30	2,07	1113,18	1114,37	1115,32	+0,035	-0,029
546	1114,38	1114,62	17,31	2,07	1112,78	1113,96	1114,92	+0,037	-0,027
546	1117,96	1118,20	17,32	2,06	1116,42	1117,61	1118,57	+0,032	-0,033
545	1099,19	1099,45	17,36	2,07	1097,68	1098,84	1099,80	+0,032	-0,032
544	1109,54	1109,79	17,33	2,07	1108,00	1109,18	1110,14	+0,032	-0,031
545	1129,66	1129,91	17,34	2,06	1128,04	1129,24	1130,22	+0,037	-0,027
361	1098,94	1099,09	17,35	2,24	1097,45	1098,62	1099,56	+0,029	-0,042
362	1115,92	1116,09	17,36	2,24	1114,45	1115,63	1116,59	+0,025	-0,045
362	1103,63	1103,81	17,40	2,24	1102,11	1103,28	1104,24	+0,031	-0,038
362	1099,94	1100,11	17,38	2,24	1098,44	1099,61	1100,56	+0,030	-0,040
362	1105,85	1106,04	17,38	2,24	1104,40	1105,57	1106,53	+0,025	-0,044
361	1096,26	1096,44	17,38	2,24	1094,72	1095,88	1096,83	+0,034	-0,036
361	1120,56	1120,74	17,41	2,25	1119,14	1120,33	1121,30	+0,021	-0,050
362	1109,74	1109,93	17,39	2,24	1108,25	1109,43	1110,39	+0,029	-0,041
362	1119,97	1120,16	17,41	2,24	1118,45	1119,64	1120,61	+0,030	-0,040
362	1116,67	1116,85	17,41	2,24	1115,24	1116,42	1117,39	+0,022	-0,049
176	639,30	639,36	17,43	2,41	638,40	639,07	639,62	+0,035	-0,041
177	642,27	642,34	17,47	2,41	641,40	642,08	642,64	+0,029	-0,047
175	664,46	664,53	17,49	2,41	663,60	664,30	664,89	+0,023	-0,054
74	669,41	669,47	17,54	2,51	668,50	669,21	669,80	+0,030	-0,049
74	666,65	666,72	17,58	2,51	665,75	666,46	667,05	+0,029	-0,049
74	686,65	686,72	17,62	2,51	685,71	686,43	687,05	+0,032	-0,047

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13 Used instruments

13.1 Instruments of BIM-NCM

The following instruments were used during the comparison

Parameter	Make	Range*	Resolution	Traceability
150 kg scale	Sartorius Germany	0 – 150 kg	0.001 kg	BIM-NCM
600 kg scale	Sartorius Germany	0 – 600 kg	0.020 kg	BIM-NCM
Water temperature	Germany	15-25 °C 15-25 °C	0.1 °C 0.1 °C	BIM-NCM
Water pressure	Bulgaria	0-5 bar 0-5 bar	0.1 bar 0.1 bar	BIM-NCM
Air temperature	Thermo-hygrometer, Germany	17-27 °C	0.1 °C	BIM-NCM
Air humidity	Thermo-hygrometer, Germany	33-77%rh	1 %rh	BIM-NCM
Air pressure	STS Sensor Technik AG, Germany	280-1005 hPa	0.1 hPa	BIM-NCM

*Calibrated range

13.2 Instruments of VSL

The following instruments were used during the comparison

Parameter	Make	Range*	Resolution	Traceability
600 kg scale	Mettler Toledo	0 – 600 kg	0.005 kg	VSL
10000 kg scale	Wöhwa	0 – 10000 kg	0.05 kg	Eegema RvA K081 VSL
Water temperature RTD's (4x)**	Eriks/Tempcontrol	10 – 30 °C	0.01 °C	VSL
Water pressure Transmitters**	GE Sensing/ Rosemount	0 – 5 bar(g)	0.01 bar(g)	VSL
Air temperature	Novasina	10 – 30 °C	0.01 °C	VSL
Air humidity	Novasina	20 – 90 %	0.1%	VSL
Air pressure	GE Sensing	970 – 1050 hPa	0.01 hPa	VSL

*Calibrated range

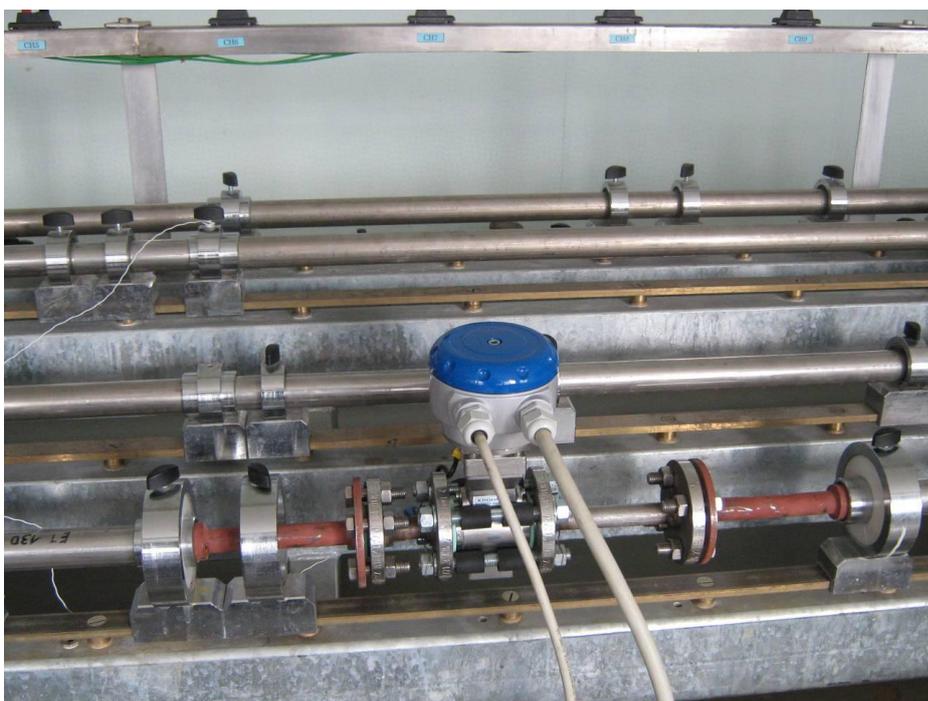
** Both up and down stream where measured, only upstream was used for comparison

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14 Pictures from tests

14.1 Pictures at BIM-NCM



Optiflux 5000



CMF200

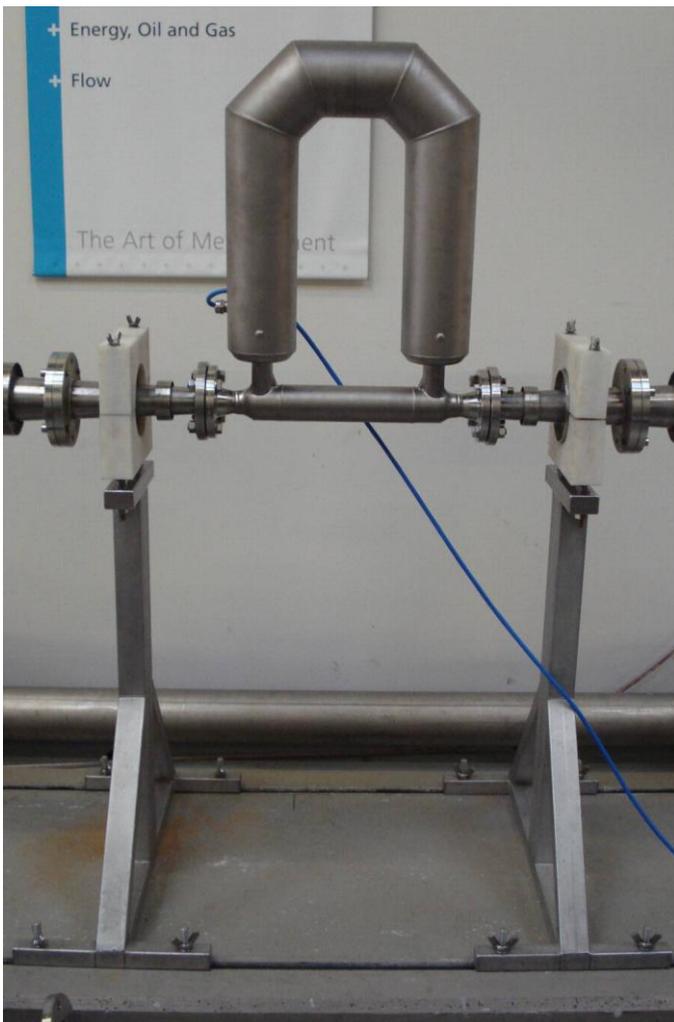
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14.2 Pictures at VSL



Optiflux 5000



CMF200

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Reference documents

- 1 Euramet Guide no. 3 "Euramet Guidelines on Conducting Comparisons".
- 2 ILAC guideline G13 "ILAC Guidelines for the Requirements for the Competence of Providers of Proficiency Testing Schemes"
- 3 JCGM 100:2008 "Evaluation of measurement data — Guide to the expression of uncertainty in measurement"
- 4 EA 4/02 Expression of the Uncertainty of Measurement in Calibration