CZECH METROLOGY INSTITUTE

Final Report – Draft B

Inter-laboratory calibration comparison of the rotary piston gas meter G650

EURAMET Project No. 1296

EURAMET

Flow

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Contents

1. Introduction

The project EURAMET no.1296 for the comparison of the rotary piston gas meter G650 officially started in March 2014 and was concluded in January 2015. The planned time schedule is mentioned down in *table 1*. Each country took three weeks to perform the calibration of the rotary piston gas meter G650 with air in the pressure which is close to barometric pressure. The range of flow rates was from 20 m^3/h to 1000 m^3/h. The participating laboratories used their usual calibration procedure. The comparison was conducted with respect to guidelines[1)].

Three participant of this project Germany (PTB), Slovak Republic (SMU) were also participants in the *CIPM key comparison CCM.FF-K6.2011* which covers flow rates only from 2 m^3/h to 100 m^3/h. Hence, in the moment when this report is issued, no CIPM key comparison was finished in the field of low pressure gas flow in relevant flow rates. That is why this inter-comparison is EURAMET supplementary comparison.

Table 1 – Time schedule and participants

Country	Laboratory	Address of the place of calibration	Date of calibration	Responsible person
Czech Republic (PILOT LAB)	CMI Czech Metrology Institute	CMI Regional Inspectorate Pardubice Husova 10, 539 73 Skuteč, Czech Republic	10.3.2014- 31.3.2014	Tomas Valenta
Germany	PTB Physikalisch-Technische Bundesanstalt	PTB Bundesallee 100 38116 Braunschweig Germany	31.3.2014- 21.4.2014	Bodo Mickan
Lithuania	Lithuanian Energy Institute	Lithuanian Energy Institute Heat Equipment Research and Testing Laboratory Breslaujos str. 3, LT-44403 Kaunas-35, Lithuania	21.4.2014- 12.5.2014	Arūnas Stankevičius
Poland	GUM Główny Urząd Miar (Central Office of Measures)	Central Office of Measures 00-950 Warszawa P-10 ul. Elektoralna 2 Poland	12.5.2014- 2.6.2014	Arkadiusz Zadworny

1) for CIPM key comparisons
http://www.bipm.org/utils/en/pdf/guidelines.pdf

Country	**Laboratory**	**Address of the place of calibration**	**Date of calibration**	**Responsible person**
Denmark	FORCE Technology	FORCE Technology, Vejen, Navervej 1 6600 Vejen Denmark	2.6.2014 23.6.2014	Kurt Rasmussen
Netherlands	VSL (Van Swinden Laboratorium) Dutch Metrology Institute	VSL Thijsseweg 11 2629 JA Delft The Netherlands	23.6.2014 14.7.2014	Mijndert P. van der Beek
Spain	CEM (Centro Español de Metrología) Enagas S.A.	Laboratorio Central Enagas Carretera de Madrid, km 306,4 50012 Zaragoza Spain	14.7.2014 4.8.2014	Nieves Medina
Austria	BEV Bundesamt für Eich- und Vermessungswesen	BEV Arltgasse 35 A-1160 Wien Austria	4.8.2014 25.8.2014	Manfred Macek
Hungary	Hungarian Trade Licensing Office (MKEH)	Flogiston Kft. H-2000 Szentendre, Kőzúzó u.5. Hungary	25.8.2014 15.9.2014	Csaba Czibulka
Slovak Republic	SMU Slovak Institute of Metrology	ELSTER s.r.o. Nám. Dr. A. Schweitzera 194 916 01 Stará Turá Slovak Republic	15.9.2014 6.10.2014	Vlastimil Zámečník
Czech Republic (PILOT LAB)	CMI Czech Metrology Institute	CMI Regional Inspectorate Pardubice Husova 10, 539 73 Skuteč, Czech Republic	6.10.2014 27.10.2014	Tomas Valenta
Switzerland *(ATA-CARNET)*	METAS Federal Institute of Metrology	Federal Institute of Metrology METAS Laboratory Flow and Hydrometry, Lindenweg 50, CH-3003 Bern-Wabern	27.10.2014 17.11.2014	Marc de Huu

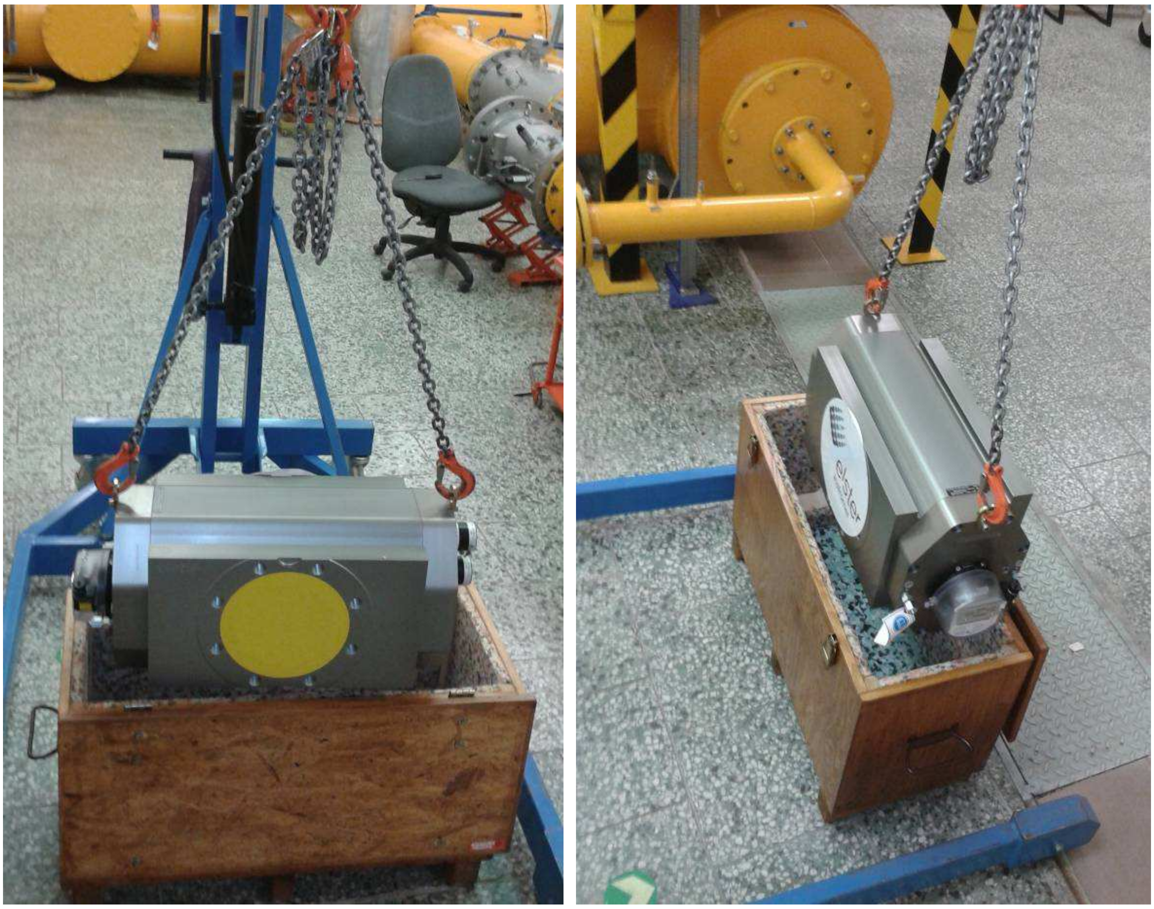
Country	Laboratory	Address of the place of calibration	Date of calibration	Responsible person
Bosnia and Herzegovina *(ATA-CARNET)*	Institut za mjeriteljstvo Bosne i Hercegovine	KJKP Sarajevogas d.o.o. Rajlovačka bb, 71000 Sarajevo, Bosnia and Herzegovina	17.11.2014 8.12.2014	Ernad Borovac Ramiz Causevic
Turkey *(ATA-CARNET)*	TÜBİTAK UME	TÜBİTAK UME Akışkanlar Laboratuarları / Fluid Flow Laboratories TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze / KOCAELİ, Turkey	8.12.2014 29.12.2014	Hakan KAYKISIZLI
Czech Republic (PILOT LAB)	CMI Czech Metrology Institute	CMI Regional Inspectorate Pardubice Husova 10, 539 73 Skuteč, Czech Republic	29.12.2014 19.1.2015	Tomas Valenta

2. The instrument

The rotary piston gas meter (*Fig. 1*) was used for the comparison. The description of this meter is mentioned down.

Manufacturer: ELSTER INSTROMET, Stará Turá, Slovak Republic	
EC-type examination certificate: T10198 (NMi)	P_{max} : 16 bar
Size: G650	Inside diameter: DN150
Serial number: 20533071 / 2013	Pulse number: 450,238 imp/m^3
Q_{min} : 6 m^3/h	Q_{max} : 1000 m^3/h
Weight: approximately 62 kg	

Figure 1 – Rotary piston gas meter IRM-3-DUO G650 ELSTER

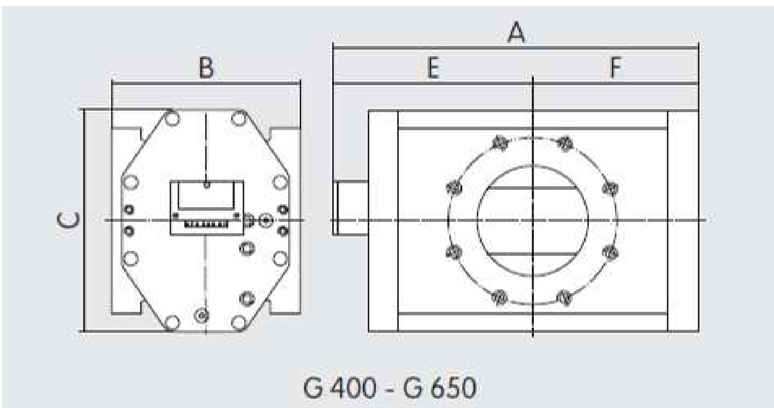


The dimensions of the meter are mentioned in *table 2* and in the *figure 2.*

Table 2 - Dimensions of the meter

Nominal diameter DN	A	B	C	E	F
150	598 mm	260 mm	308 mm	336 mm	262 mm

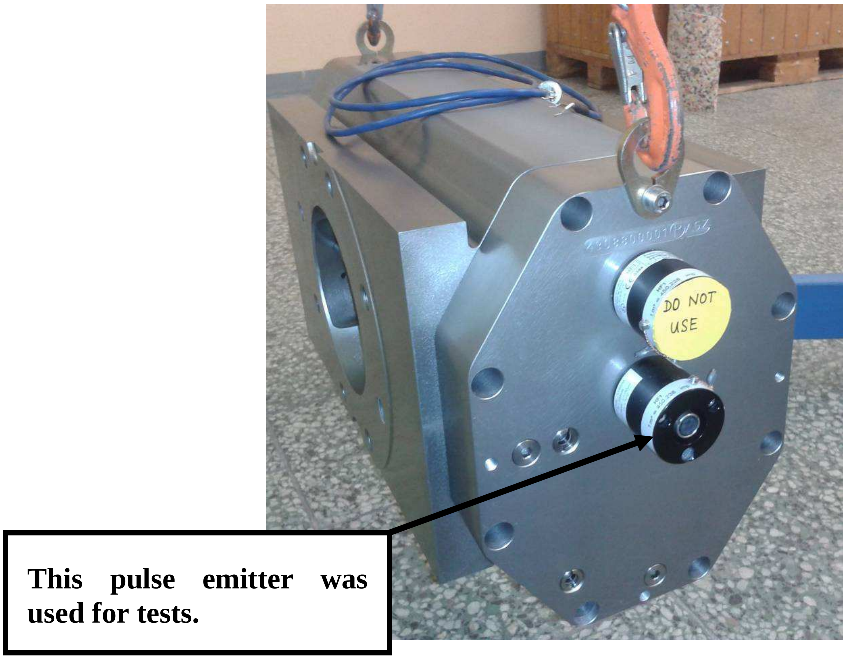
Figure 2 - Dimensions of the meter



The HF pulse generator type REPROX was be used. Only one of two HF pulse generators was used. The right one was labelled. This emitter is made according to EN 60947-5-6 (NAMUR). The pulse emitter is mentioned in the *figure 3* and in the *figure 4*.

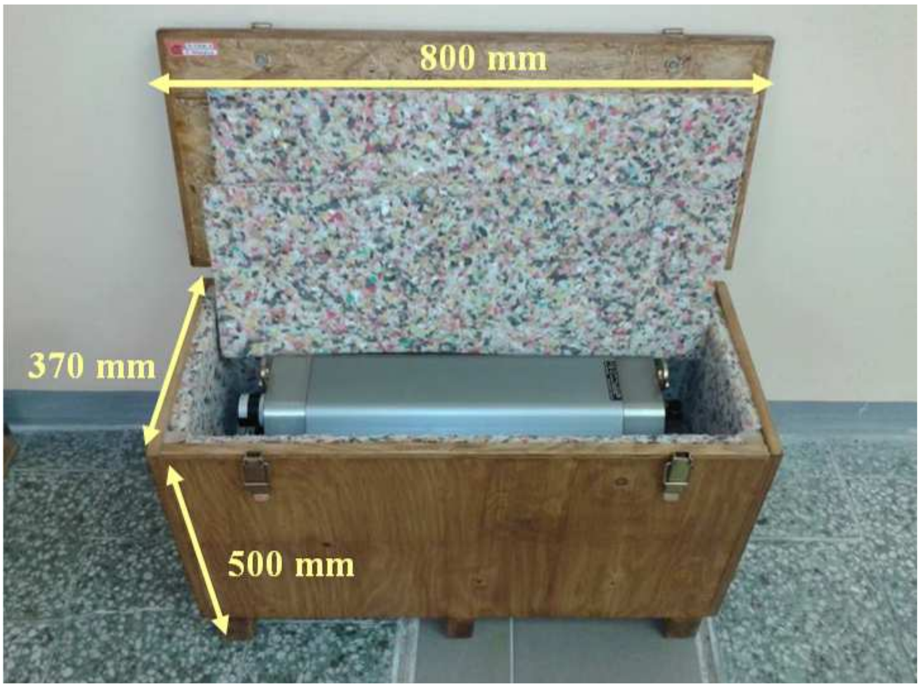
Figure 3 – HF pulse emitter REPROX

Figure 4 – HF pulse emitter determined for tests



The meter was packed in wooden box that is mentioned in the *figure 5*. The diameter of the box was (800x370x500)mm. The weight of the complete box with the meter was approximately 75 kg.

Figure 5 – The wooden box for the rotary piston gas meter G650



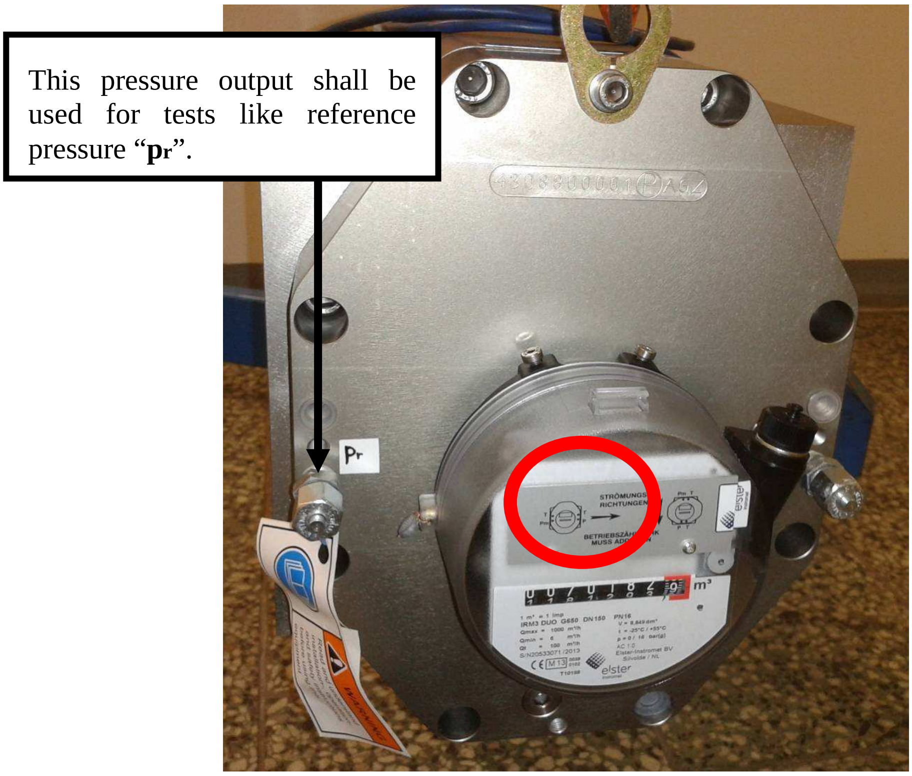
In the box there was the meter, a pulse emitter connector and the copy of *Technical protocol*.

3. Calibration procedure

The participating laboratories could use their usual calibration procedure. Only instructions mentioned down had to be fulfilled.

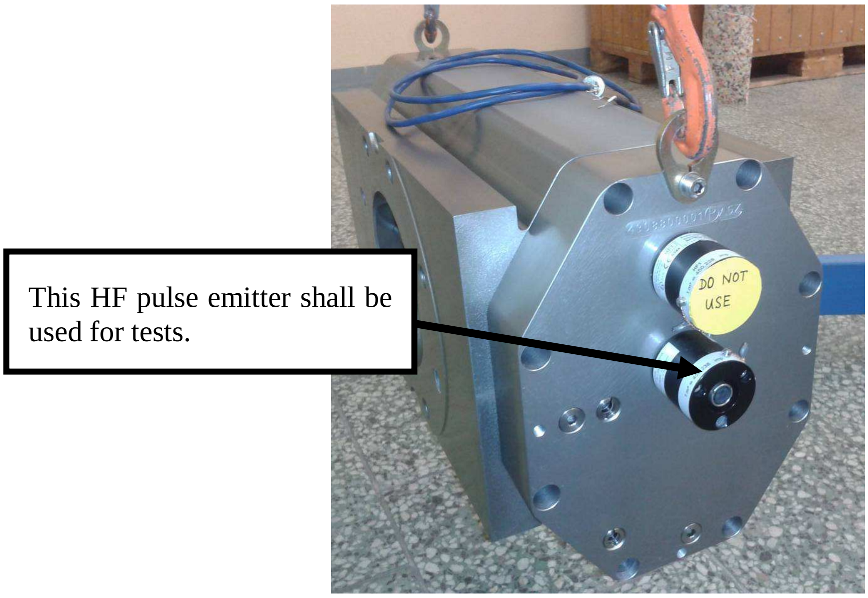
- The rotary piston gas meter has to be tested in horizontal position by air near barometric pressure.
- The upstream straightening pipe of the length at least 5xDN shall be used.
- The reference temperature from the rotary piston gas meter should be measured in the distance (2÷3)x DN downstream of the rotary piston gas meter.
- The test should be performed in the laboratory where the temperature is from 19.5°C to 23.5°C. The upstream pressure of the meter should be near atmospheric pressure.
- Before the beginning of the test the gas meter has to work 20 minutes in a flow rate Q=400 m^3/h.
- The reference pressure from the rotary piston gas meter has to be measured from the output "p_r". This pressure output "p_r" is in the inlet (upstream) of the gas meter (*Figure 6*).

Figure 6 – The pressure output “p_r” of the rotary piston gas meter G650



- It is necessary to use only a HF pulse emitter for the tests. The right HF pulse emitter is the one which is close to the centre of a gas meter. The correct one is not labelled “DO NOT USE” (*Figure 7*).

Figure 7 – HF pulse emitter for the tests of the rotary piston gas meter G650



- The rotary piston gas meter has to be tested in 10 flow rates: 1000 m^3/h, 800 m^3/h, 650 m^3/h, 450 m^3/h, 350 m^3/h, 250 m^3/h, 160 m^3/h, 100 m^3/h, 50 m^3/h, 20 m^3/h.
- The test in one flow rate should be repeated at least 3 times and then the means of values in the *table 3* have to be calculated. The flow rate has to be in the interval ± 3% of the required value.
- The one single test in one flow rate has to take more than 3 minutes. Beforehand the flow rate has to be accurately stabilised.
- Each participant has to record the results in the form of *table 3* mentioned down.

Table 3

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter
(m^3/h)	(Pa)	(°C)	(Pa)	(%)
1000				
800				
650				
450				
350				
250				
160				
100				
50				
20				

Error of the meter is value which shows the relationship in percentage terms of the difference between the volume indicated by the meter and the volume which has actually flowed through the meter, to the later value.

$$E = \frac{V_i - V_c}{V_c}.100 \qquad (\%) \qquad [1]$$

where E is the error of the meter
V_i is the indicated volume by the meter (m^3)
V_c is the real volume which has actually flowed through the meter (m^3)

4. Test facility and obtained results

4.1. Germany

Description of the Nozzle Test rig

The nozzle test rig (*Figure 8*) for large gas meters (2 - 5600 m³/h) was used for the calibration of the rotary piston gas meter G650.

Figure 8 - PTB test bench for large gas meters

The computer-controlled nozzle test rig consists of an echelon of 16 Venturi nozzles connected in parallel and operated at sound velocity. This mode of operation guarantees a very high stability of the flow rate selected, with short-term reproducibilities of 0.002%. The uncertainty of measurement amounts to U < 0.08%.

The sonic nozzle test bench is a secondary standard with traceability to the bell prover (1 - 60 m^3/h). A bell prover which allows volume flow rates of air at atmospheric pressure to be realized with a measurement uncertainty of U < 0.06% serves as the primary standard in Germany and the one is situated in PTB.

Place of calibration: Physikalisch-Technische Bundesanstalt (PTB)
Bundesallee 100, D-38116 Braunschweig, Germany

Results of PTB:

Flow rate in the meter	Real test flow	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m^3/h)	(m^3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	1020.652	99504	20.857	767.7	0.167	0.080
800	815.682	99619	20.873	493.9	0.096	0.081
650	665.757	99677	20.883	331.6	0.156	0.080
450	460.590	99738	20.933	162.5	0.229	0.080
350	360.043	99751	21.003	100.5	0.234	0.080
250	256.655	99737	21.100	53.9	0.227	0.080
160	163.633	99709	21.170	23.8	0.348	0.080
100	99.944	99688	21.230	10.3	0.311	0.080
50	48.934	99673	21.253	3.8	0.259	0.080
20	20.172	99638	21.227	2.1	0.041	0.080

4.2. Lithuania

Place of the test

Heat equipment research and testing laboratory of Lithuanian energy institute, 3 Breslaujos str. LT-44403 Kaunas-35, Lithuania

The test method

During the test the rotary piston gas meter was calibrated by the method of comparison the meter's readings with readings of a standard gas meters. The calibration was carried out according to the document KM-2E/3-MP01:2004 «Air (gases) volume and flow rate meters, (1 – 9700) m^3/h. Methods of calibration».

According to the Technical Protocol for EURAMET Project No. 1296 "Inter-laboratory Calibration Comparison of the Rotary Piston Gas Meter G650" the gas meter has was calibrated at 10 values of flow rate: (1000, 800, 650, 450, 350, 250, 160, 100 , 50, 20) m^3/h.

Before the beginning of the test the gas meter worked 20 minutes at flow rate Q = 400 m^3/h.

Round tubes of diameter DN150 were used as straight pipes. The length of upstream straight pipe was L_1=1.8 m (12 DN), downstream – L_2=1 m (6.7 DN).

The thermometer for measurement of the air flow temperature was installed at the distance of 0.4 m (2.7 DN) downstream of the gas meter

The deviation of real flow rate values did not exceed ± 3% of the required values.

The test at each flow rate was repeated at least 3 times and then the means values were calculated.

The test facility

The standard facility No. 2E/3 with reference gas meters was used for calibration. The main characteristics of the facility: measurement range is (1 – 9700) m^3/h, the calibration and measurement capability in the range of flow rate (1 – 1600) m^3/h is ± 0,25 %.

The facility was calibrated 17.12.2012, certificate of calibration No. 180/12-L.

The general view of the facility is presented at *Figure 9.*

Ambient conditions

Atmospheric pressure (1010 ± 5) mbar; temperature (20,1 ± 0,5) °C; relative air humidity (60 ± 5) %.

Traceability

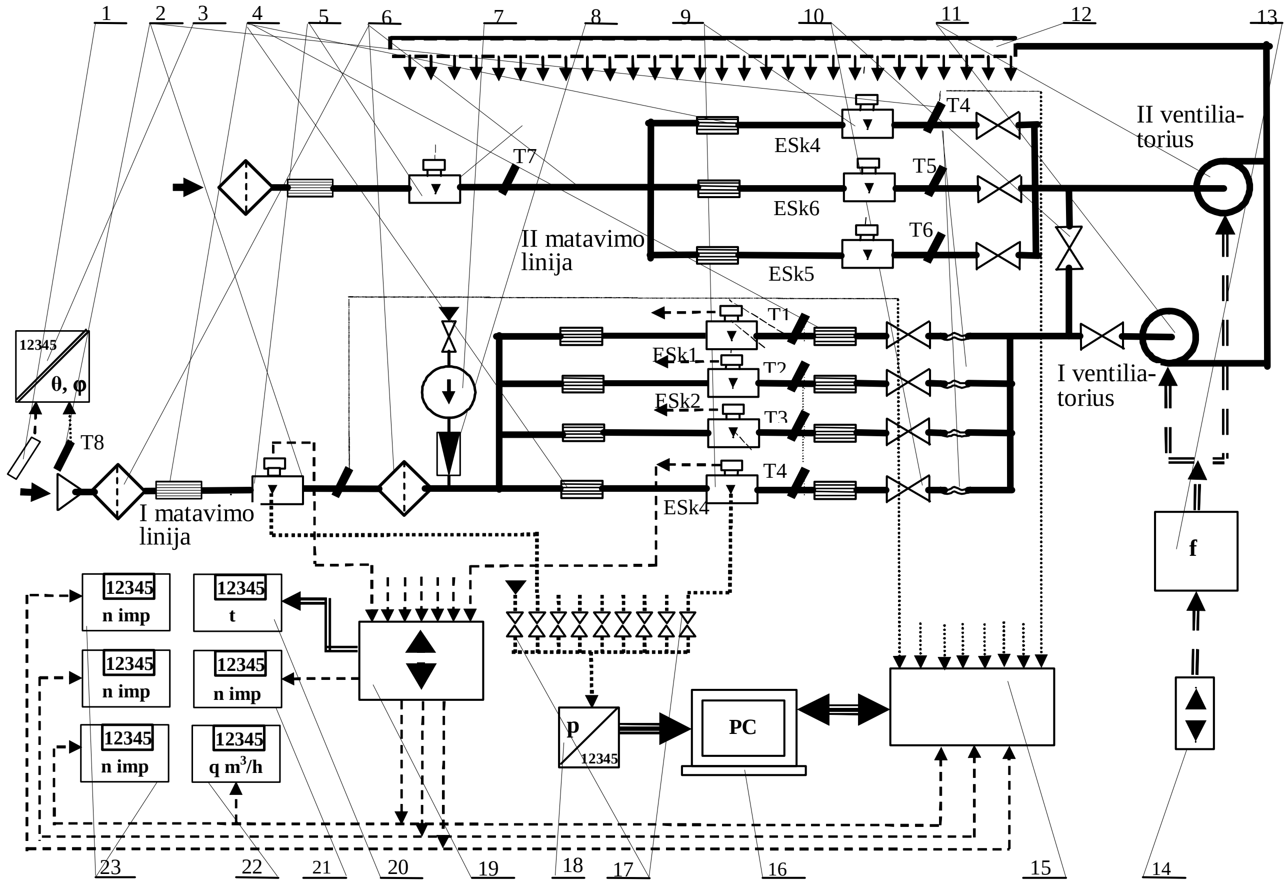
Two reference gas meters were used for calibration:

1. Rotary piston gas meter IRM-A-DUO, G100, DN80, Q_{max}= 160 m^3/h, production of the company "INSTROMET" (Belgium), S/N 311006, calibrated by PTB (Germany), calibration certificate No.14003/13PTB of 16.01.2013 (recalibration interval - 5 years).
2. Turbine gas meter CGT-2, G1000, DN200, Q_{max}= 1600 m^3/h production of the company "COMMON" (Poland), S/N 510136, calibrated by PTB (Germany), calibration certificate No.14081 PTB 11 of 08.04.2011 (recalibration interval - 5 years).

The temperature, pressure and time measurement devices are traceable to the Lithuanian national standards.

Figure 9 - The scheme of the standard facility in Heat equipment research and testing laboratory of Lithuanian energy institute

1 – humidity sensor; 2 – thermometers; 3 – temperature and humidity transducer; 4 – flow straightener; 5 – meter under calibration; 6 – air filter; 7 – compressor; 8 – pressure reducer; 9 – reference gas meters; 10 – valves; 11 – fans; 12 – distributing air collector; 13 – frequency converter; 14 – controller of frequency converter; 15 – data acquisition and measurement device; 16 – personal computer ; 17 – pressure tapping connecting valves; 18 – absolute pressure meter; 19 – device of synchronization of time measurement and pulses counting; 20 – timer; 21 –; 22 – electronic flow rate indicator; 23 – reference meters pulses counters.



The general view of the facility is presented at *Figure 10*.

Figure 10 - The general view of the standard facility in Heat equipment research and testing laboratory of Lithuanian energy institute

Test results:

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m^3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	100697	20.18	728	0.12	±0.25
800	100857	20.17	475	0.08	±0.25
650	100945	20.19	314	0.18	±0.25
450	101055	20.22	156	0.19	±0.25
350	101090	20.25	95	0.22	±0.25
250	101120	20.27	51	0.25	±0.25
160	101123	20.29	24	0.31	±0.25
100	101135	20.30	12	0.37	±0.25
50	101140	20.28	5	0.35	±0.25
20	101141	20.30	3	0.15	±0.25

4.3. Poland

Test facility: Bell prover
Range of flow rate: (9 to 7000) m^3/h
Working pressure: atmospheric conditions
Situated: Central Offices of Measures,
ul. Elektoralna 2, 00-139 Warszawa, Poland

Treaceability: The standard is related to national standards of length, time, pressure, temperature

Test procedure: Calibration of a gas meter is carried out by determination of the error-flow rate relationship. Errors of the calibrated gas meter are calculated as a ratio of the difference of the volume measured by the gas meter and the reference volume to the reference volume. The reference volume is determined on the basis of measurement dose of the bell prover and calculated to the conditions of the gas meter. The volume measured by a gas meter is calculated by multiplying number of high frequency pulses by the pulse generator constant.

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U (k=2)
m^3/h	Pa	°C	Pa	%	%
1000	104031	23.06	–	0.08	0.26
800	103821	23.16	–	0.08	0.27
650	104258	23.02	–	0.17	0.27
450	103941	23.18	–	0.15	0.27
350	104372	23.03	–	0.22	0.27
250	104005	23.21	–	0.24	0.27
160	104387	22.98	–	0.26	0.27
100	104023	23.14	–	0.30	0.28
50	104354	22.96	–	0.40	0.28
20	104195	23.11	–	0.35	0.33

4.4. Denmark

Description of the test facility

The tests were performed at the Danish National Reference Laboratory for volume gas measurement located at:

FORCE Technology
Navervej 1
DK-6600 Vejen
Denmark

The tests were performed on test line FORCE no.C02-001 and are a comparison of the volume indicated by the device under test (DUT) and the corrected volume indicated by the reference meter, The DUT is placed before the reference meter (upstream). The air is sucked trough the DUT and then the reference meter. The pressure at the DUT and at the Reference meter is measured at the Pr point and the temperatures at both meters are measured 2D downstream.
The temperature is measured with thermistors, and the pressure is measured with differential pressure meter. The test line consists of 3 different rotary piston meters (one Oval meter and two CVM meters) as reference meters. The tes tline can operate at a flow from 1 m^3/h to 400 m^3/h.

Traceability of the working standards and other equipment:
The working standards are traceable to the VSL in Delft in Holland, and are being recalibrated every year. The thermistors are traceable to NPL in England.
The differential pressure meters are traceable to the National Reference Laboratory in Denmark.

Uncertainty:
The uncertainty of the calibration is in accordance with EA-4/02 "Expression of the Uncertainty of Measurement in Calibration", December 1999:
Atmospheric test line C02-001: 1< Q < 4 m3/h Ua = 0.20 %
4 < Q < 400 m3/h Ua= 0.18 %

Results of Denmark:

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m^3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	-	-	-	-	-
800	-	-	-	-	-
650	-	-	-	-	-
450	-	-	-	-	-
350	100578	20,34	-	0,33	±0,18
250	100539	20,23	-	0,26	±0,18
160	100552	20,27	-	0,27	±0,18
100	100567	20,26	-	0,33	±0,19
50	100583	20,28	-	0,34	±0,18
20	100628	20,31	-	0,20	±0,19

4.5. The Netherlands

The G650 rotary meter used for this inter-comparison has been calibrated on the VSL calibration facility, named the 'Large Test Facility' (LTF). This facility (*Figure 11*) is located at VSL, Low Pressure Flow laboratory in Delft, Thijsseweg 11, The Netherlands.

The LTF consists of two axial blowers, one for low flow rates (up to 4000 m^3/h) and one for high flow rates (up to 15000 m^3/h), a regulated heat exchanger after the blowers, a data acquisition system, software, piping, pressure and temperature sensors and five reference meters. The reference meters are described below in table :

Standard no.	Type	Manufacturer	Range
2	G250 IRM-A-DUO rotor meter	Instromet	15 - 400 m3/h
3	G650 SM-RI-X turbine meter	Instromet	175 - 1130 m3/h
4	G2500 SM-RI-X-E turbine meter	Instromet	1000 – 4190 m3/h
5	G4000 SM-RI-D turbine meter	Instromet	1200 – 6600 m3/h
6	G6500 SM-RI-D Turbine meter	Instromet	3000 – 10000 m3/h

In this inter-comparison reference meter with number 2 and 3 are used within the range of the G650 rotary meter. When possible, overlap measurements between the two VSL reference meters has been performed.

Results of The Netherlands:

Nominal Flow rate	Measured Flow rate	Absolute pressure at Pr	Temperature at the outlet	Differential pressure	Error of the meter	Uncertainty of the error U(k=2)
(m3/h)	(m3/h)	(Pa)	(oC)	(Pa)	(%)	(%)
1000	1002	102505	19.80	747	0.14	0.15
800	800	102232	19.73	478	0.09	0.15
650	649	102070	19.69	314	0.19	0.15
450	450	101906	19.69	153	0.21	0.15
350	351	101826	19.70	92	0.24	0.15
250	249	101754	19.74	46	0.29	0.15
160	161	101715	19.76	20	0.30	0.15
100	99.9	101697	19.76	8	0.31	0.15
50	50.0	101682	19.77	1	0.33	0.15
20	20.1	101683	19.78	0	0.15	0.15

The reference meters are all traceable to primary and/or (inter) nationally accepted measurement standards. The recalibration interval of the reference meters is three years.

The CMC of the installation within the range of (15 – 15000) m^3/h is 0.15 %.

The test procedure used by VSL is the test procedure as outlined in the Technical Protocol for EURAMET Project No. 1296. As an addition to this procedure the temperature of the reference meters and the meter under test are monitored during each flow rate. Once stabilization has occurred, the measurement is started.

Figure 11 - 'Large Test Facility' (LTF) in VSL

4.6. Spain

Test facility

The calibration has been performed in the Enagás Central Laboratory (Gas Meter Laboratory) sited in the following address:

Enagás, S.A.
LABORATORIO DE CONTADORES DE GAS
Autovía A-2, km. 306,4. 50012 – ZARAGOZA (SPAIN)

This laboratory is a subcontractor of Centro Español de Metrología (CEM).

The test bench (as shown in *figures 12 & 13*) consists of five working standard meters, which are periodically calibrated by means of three reference standard meters (with traceability to international standards). Both working and reference meters are described in the following table:

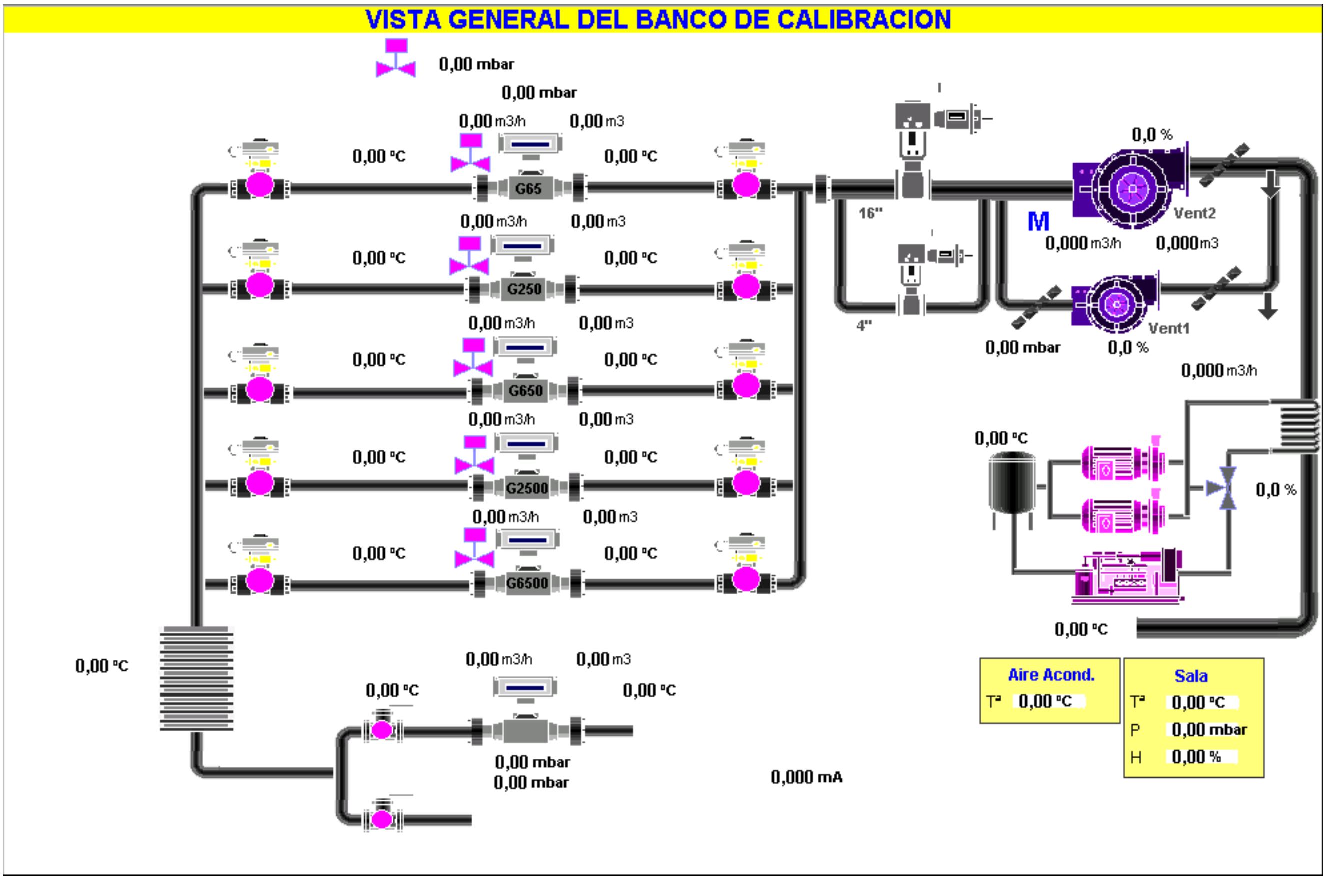
Working Standard Meters			Reference Standard Meters		
Item	**Type**	**Size**	**Item**	**Type**	**Size**
1	Turbine	G 6500	1	Turbine	G 6500
2	Turbine	G 2500			
3	Turbine	G 650	2	Turbine	G 650
4	Turbine	G 250			
5	Rotary displacement	G 65	3	Rotary displacement	G 65

The flow rate range covered with these standard meters is 5 m^3/h to 10000 m^3/h. The fluid used for calibration is air at a pressure close to atmospheric pressure. The laboratory air temperature is within the range 20 ºC ± 1 ºC.

The facility is equipped with the necessary equipment for the measurement of gauge and barometric pressure [mbar], temperature [ºC], and pulses (high and low frequency). All this instruments are also calibrated by means of internal procedures and its measurements are traceable to national standards.

Figure 12 - Enagás test bench

Figure 13 – Enagás test bench diagram



Test procedure

The calibration has been performed according to the following procedure:

- Meter reception, registration and previous inspection.
- Temperature conditioning: before calibration the meter has remained a minimum of 24 hours in the test facilities for temperature conditioning.
- Leakage test: the test facility (including the meter) has been tested for leakage previous to calibration.
- Run-in-period: the meter has undergone a run-in-period of not less than 20 minutes at the flow rate Q=400 m³/h before calibration.

Calibration:

- The calibration has been carried out with air which pressure was close to atmospheric pressure. The laboratory temperature was 20 ºC ± 1 ºC.
- The error determination of the meter is based on the comparison of the air volume which was indicated by the standard meter and the air volume which was indicated by the meter under test after calculations of corrections concerning temperature and pressure differences in the standard meter and the meter under test.
- The reference pressure of the rotary piston gas meter has been measured through the output “pr”. The pressure loss of the meter has been measured between the output “pr” and the meter outlet.
- The calibration has been performed by means of the high frequency pulse emitter.

- The minimum volumes established for each nominal calibration flow rate were the following (3-minute minimum test time):

Flow rate (m³/h)	1000	800	650	450	350	250	160	100	50	20
Volume (m³)	60,0	48,0	39,0	27,0	21,0	15,0	9,6	6,0	3,0	1,2

- Deviation between nominal test flow rates and real test flow rates has been less than ±3 %.
- At each flow rate the error has been determined three times without changing the flow rate.
- Determination of the error of the meter (average of three values obtained at each flow rate) and its uncertainty.

Traceability

The traceability of the working standard meters and other measuring instruments which were used during the test, as well as their corresponding recalibration intervals, are shown in the following table:

Item	***Traceability***	***Recalibration Intervals***
Working standard meter G 6500	PTB	1 year
Working standard meter G 2500	PTB	1 year
Working standard meter G 650	PTB	1 year
Working standard meter G 250	PTB	1 year
Working standard meter G 65	PTB	1 year
Temperature meters	CEM	2 years
Gauge pressure meters	CEM	2 years
Barometric pressure meter	CEM	2 years
Pulse counter	CAT	1 year

Results of Spain:

Flow rate in the meter (m³/h)	**Absolute pressure in the meter (Pa)**	**Temperature in the meter (ºC)**	**Pressure loss of the meter (Pa)**	**Error of the meter (%)**	**Uncertainty of the error *U* (*k*=2) (%)**
1000	96909	19,66	480	-0,22	0,39
800	97109	19,62	319	-0,05	0,39
650	97232	19,55	218	0,01	0,39
450	97372	19,49	113	0,12	0,39
350	97456	19,49	73	0,23	0,39
250	97489	19,50	41	0,25	0,39
160	97486	19,53	21	0,30	0,39
100	97473	19,55	11	0,36	0,41
50	97460	19,56	6	0,28	0,42
20	97463	19,59	4	0,36	0,42

4.7. Austria

Location:
Bundesamt für Eich- und Vermessungswesen (**BEV**)
Arltgasse 35
A-1160 Wien, Austria

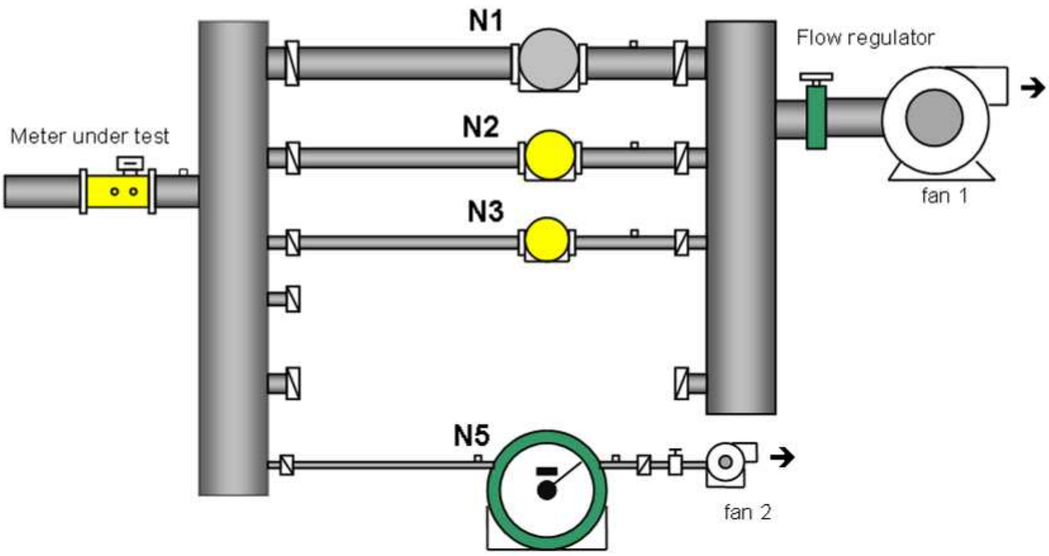
Characteristic information of the test bench *(Figure 14):*

Maximum flow rate: 1000 m³/h
Minimum flow rate: 0,1 m³/h
Working pressure: atmospheric conditions
Uncertainty (k=2): 0,30 %

Normal meters:

	type	size	used range	manufacturer
N1	Rotary piston meter (DUO)	G650	10 to 1000 m³/h	Instromet
N2	Rotary piston meter (DUO)	G250	4 to 400 m³/h	Instromet
N3	Rotary piston meter (DUO)	G40	1 to 65 m³/h	Instromet
N4	Rotary piston meter	G16	0,5 to 25 m³/h	Instromet
N6	Wet drum meter	NB3	0,1 to 3 m³/h	Elster

Figure 14 – BEV test bench diagram



Traceability:
For flow rates between 1000 m³/h and 25 m³/h, the normal meters are traceable to the VSL (Netherlands). For flow rates between 25 m³/h and 0,1 m³/h, the normal meters are traceable to the BEV (bell prover).

Description of the test procedure:
The meter was installed with an upstream straightening pipe (5xDN) according to our normal practice. Air was sucked from the laboratory by a fan through the meter under test and afterwards through the chosen normal meter. The flow rate was adjusted by a valve behind the normal meter. The pressure at the test meter and the normal meter was measured on the gas meter body, at the point marked "pm", the meter temperatures where measured downstream of the meters. The duration of each test was min. 180 seconds (3 minutes). The indicated volume for the meters where calculated from the counted pulses, the flow rate was derived from measuring the time and the passed volume during one test point. The reference volume at the transfer meter was obtained by correcting the volume measured by the normal meter to the conditions of the meters.

Results of Austria:

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U (k=2)
m³/h	Pa	°C	Pa	%	%
20.0	98800	22.59	3	0.12	0.30
50.2	98790	22.70	5	0.28	0.30
100.6	98780	22.72	11	0.40	0.30
160.6	98777	22.59	25	0.38	0.30
250.5	98763	22.70	62	0.30	0.30
349.8	98750	22.58	119	0.24	0.30
450.1	98720	22.76	195	0.20	0.30
649.2	98660	22.90	396	0.16	0.30
798.4	98588	23.00	594	0.13	0.30
998.2	98467	22.80	942	0.10	0.30

4.8. Hungary

NMI: MKEH, Hungarian Trade Licensing Office

The address of the laboratory:
Flogiston Kft., H-2000 Szentendre, Kőzúzó u. 5.

This laboratory is a subcontractor of MKEH. MKEH is accredited by Hungarian Accreditation Body for calibration of gas meters at Flogiston Kft. The laboratory of Flogiston Kft. for calibration and verification of gasmeters is under control of MKEH. (Flogiston Kft. does not make calibrations without presence of MKEH represent.)

Date of calibration: 2 September 2014.
Transfer meter: rotary gas meter, ELSTER INSTROMET, IRM-3-DUO G650 DN150, SN. 20533071/2013 (*Figure 15)*

The Description of the Test Facility:
Maximum flow rate: 5600 m^3/h
Minimum flow rate: 0.5 m^3/h
Working pressure: atmospheric conditions
Uncertainty (k=2): 0.30 %

Standard meters (*Figure 16*):

Nr	Type	Manufacturer	Range
1	AAT-140 / 12” Auto-Adjust Turbo Meter	Equimeter Inc, USA	200 – 4000 m^3/h
2	AAT-60 / 8” Auto-Adjust Turbo Meter	Equimeter Inc, USA	100 – 1600 m^3/h
3	iMRM G400 DN 150 Rotary Meter	iMETER	4 – 650 m^3/h
4	G40 IRM-A-DUO DN50 Rotary Meter	Instromet	0.5 – 60 m^3/h

The installation operate on the master meter principle, comparing the output of a Meter-under-Test is connected in series with the reference meter. The quantity of gas flowing through both meters is identical by taking pressure and temperature in both meters into account the volume can be compared. The Meter-under-Test is upstream of the reference meter.

Traceability:
The standard meters are treceable to the primary standards of the VSL Netherlands.
Recalibration interval of the standard meters: 5 years
The barometer, the pressure transmitters and the temperature sensors are calibrated in period of two years.

Figure 15 – Meter under test

Figure 16 - Standard meters (Flogiston Kft)

Description of the test procedure
The transfer meter was installed according to the laboratory normal practice and according to the instructions of Project No. 1296. The meter was calibrated against the standard meters Nr.2 and Nr.4. The meter was installed with an upstream straightening pipe 5*DN and a downstream straightening pipe 3*DN. Pressure was measured at the point marked 'Pr' on the transfer meter. The temperature was measured downstream of the transfer meter. The duration of each test was about 185 seconds.
The reference volume at the transfer meter was obtained by correcting the volume measured by the standard meters to the conditions at the transfer meter. The indicated volume from the transfer meter was calculated from the pulses of HF pulse emitter, from the time and from the nominal K-factor (K=450.238 imp/m^3) of the transfer meter.

Results of Hungary:

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m^3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	99520	22.8	700	0.18	0.30
800	99690	22.5	450	0.14	0.30
650	99780	22.4	300	0.11	0.30
450	99870	22.1	150	0.20	0.30
350	99910	21.8	90	0.26	0.30
250	99930	21.8	47	0.26	0.30
160	99930	21.7	20	0.28	0.30
100	99940	21.8	9	0.32	0.30
50	99940	21.8	3	0.34	0.30
20	99940	21.8	2	0.16	0.30

4.9. Slovak republic

The comparison measurement was realised in the authorised metrological centre:
Elster s.r.o.
nám.Dr.Alberta Schweitzera 194
916 01 Stará Turá
Slovak Republic

Test facility
The test equipment type ITF2500 (*Figure. 17*) is the facility for testing industrial gas meters. The test equipment type ITF2500 operates in the range **from 0,5 m^3/h to 2500 m^3/h** with the expanded uncertainty better then U (k=2) = 0,20 %.
During the test the temperature and the pressure of air are measured both in the test equipment ITF2500 and in the meter under test. At the end of the test the means temperatures and the means pressures are calculated. The absolute pressures in the ITF2500 and in the gas meter are calculated as the sum of barometric pressure in the laboratory and the pressure loss in the standard meter or in the gas meter.
The test facility is situated in the Metrological laboratory of company ELSTER, a. s. Stará Turá. Metrological inspection of this equipment ensures by Slovak Institute of Metrology. Metrological laboratory in the company ELSTER, s.r.o. Stará Turá is authorized according Act No. 142/2000 Coll. on metrology by Slovak Office of Standards, Metrology and Testing which is a governmental institution. Authorization under this Act means granting the license to perform the verification of legally controlled measuring instruments or to carry out official measurements. This metrological laboratory is accredited by Slovak National Accreditation Service (SNAS) and has approved quality system for manufacture and final product inspection and testing of the measuring instrument according requirements of the Directive 2004/22/EC (MID) on measuring instrument, Annex D by the Notified body 1781 - Slovak Institute of Metrology. For this reason is laboratory periodically audited for fulfil requirements. Slovak Institute of Metrology (SMU) participated on these audits with technical experts. Farther metrological laboratory is under control of SMU by means of periodically external audits according quality procedures of SMU. Tests in the comparison were carried out under the supervision of technical experts of SMU and inspection of used equipment ensures SMU.

Part of the standard in test equipment consists of three, connected in parallel, standard meter. The lowest flow rates used standard rotary gas meter type IRM-A G16 ELSTER, with a measurement range of flow rates (from 0.5 up to 20.0) m^3/h. The other two branches are mounted standard rotary gas meter IRM-3 DUO, size G 650, with a measurement range of flow (from 16 up to 1250) m^3/h.

The test procedure was carried out at prescribed points of flow. The stability of the set flow rate at each point flow rate was within the range of 3 %. The test was repeated three times in each flow rate. The standards of the gas flow test equipment ITF2500 – rotary gas meters – are traceable to the Dutch national standard of gas flow. Recalibration interval is 5 years. All temperature and pressure meters are regularly calibrated once every two years with the traceability to Slovak national standard.

Figure 17 - The test equipment type ITF2500 in Elster s.r.o. Stará Turá

Figure 18 - Connecting of the MUT on the test equipment type ITF2500 in Elster s.r.o. Stará Turá

Results of Slovak Republic:

Nominal Flow rate	Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Expanded uncertainty of the error *U* (*k*=2)
(m^3/h)	(m^3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	998.62	95206	22.15	779	0.06	0.24
800	800.24	96217	22.24	510	0.10	0.24
650	649.02	96860	22.27	335	0.15	0.24
450	450.48	97522	22.30	165	0.18	0.24
350	350.26	97771	22.27	102	0.22	0.24
250	249.40	97964	22.26	52	0.23	0.24
160	159.82	98088	22.27	23	0.27	0.24
100	100.19	98141	22.27	11	0.29	0.24
50	49.68	98170	22.29	4	0.27	0.24
20	20.01	98184	22.31	2	0.06	0.24

4.10. Czech Republic

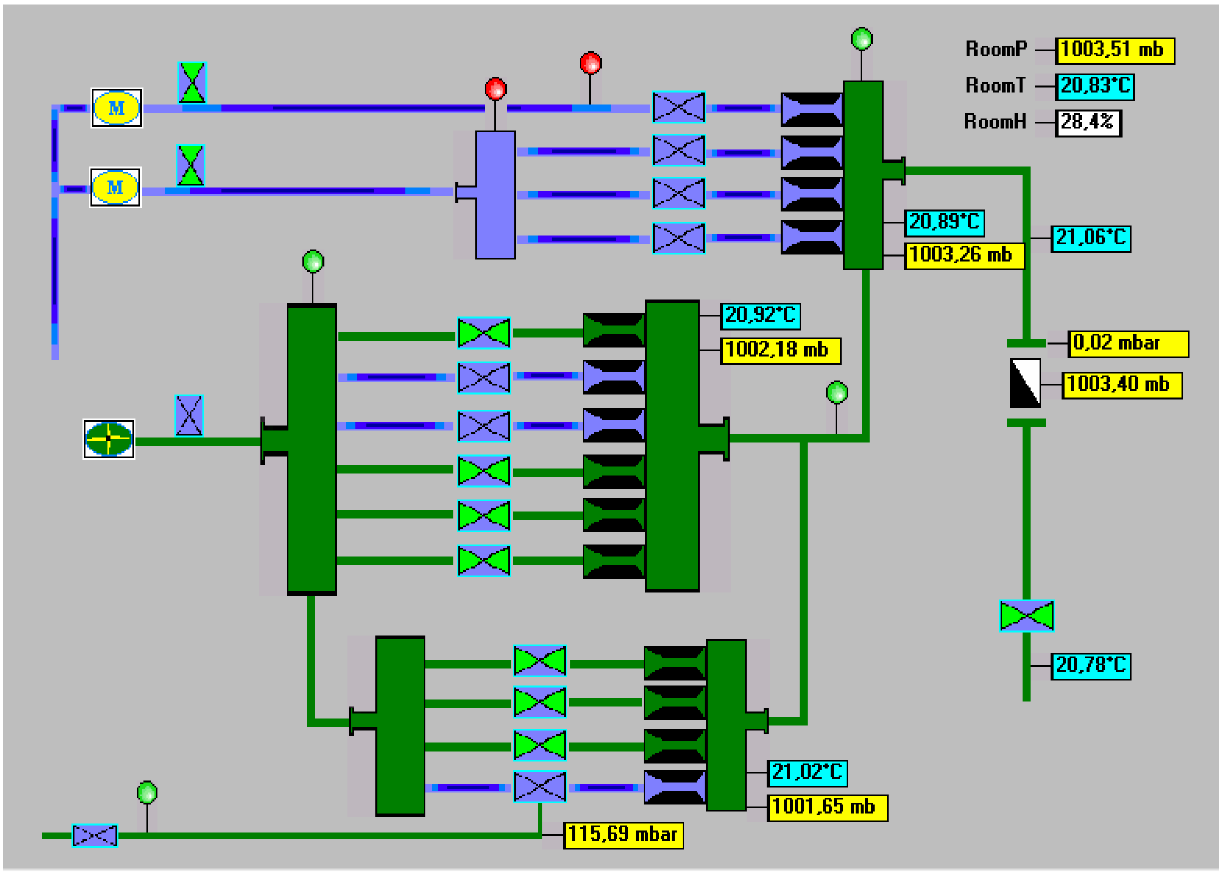
Place of calibration: Czech Metrology Institute (CMI)
Regional Inspectorate Pardubice, Gas Flow Laboratory
Husova 10
539 73 Skuteč
Czech Republic

The test bench with sonic nozzles consists of 14 nozzles which are situated in 3 blocks. The vacuum is generated by two centrifugal fans and by one vacuum pump. The clamping system of gas meter is pneumatic. There are one barometric pressure meter and six gauge pressure sensors in the test bench.

Three of gauge pressure sensors measure the negative pressures in blocks of nozzles, one of them measures the tightness of lines which are out of operation, one measures the negative pressure in gas meter (p_r) and the last one measures the pressure loss of gas meter.

Five temperature sensors measure the temperature in blocks of nozzles, in the gas meter and in the input of air to the test bench. Besides the humidity in the input of air to the test bench and the time of test are measured, too. The *Figure 19* of the test bench is mentioned down.

Figure 19 – Test bench with sonic nozzles in CMI



The flow of air reaches the critical status in nozzle and it means the constant mass flow rate of air in nozzle. By combination of different nozzles and by measurements of temperature, pressure and humidity it is possible to ensure the known volume flow rate. The test bench works in the range from 0,06 m^3/h till 1200 m^3/h.

This test bench is controlled by PC and the one works fully automatically. It is only necessary to clamp the gas meter to the test bench. Then the operator inputs the data of the gas meter and defines the required sequence of the flow rates. The measurement starts with the leakage test. The comparison of all pulse emitters of the gas meter follows. Until these two exams are successful the determination of error of the gas meter in sequence of flow rates does not begin. The measurement runs independently by automatically adjusting of the flow rates.

During the test the temperature in the blocks of nozzles and in the gas meter, the pressure in the blocks of nozzles and in the gas meter and the humidity are measured once per 2 seconds. The time of test is measured, too. The time of test in one flow rate is at least 60 seconds.

The test bench with sonic nozzles was made by Schlumberger Industries, Calibration Equipments Division, Barcelona, Spain in 1998. The type designation is SONICAL SN-1000, serial number of the bench is 330.

All sonic nozzles are calibrated by CMI. Standard gas meters with the traceability to Physikalisch-Technische Bundesanstalt (PTB) are used for the calibration of the sonic nozzles.

The 6 pieces of temperature sensors Pt100 DESIN, 6 pieces of gauge pressure sensors FEDISA, barometric pressure sensor DRUCK, pulse timer and humidity sensor VAISALA are calibrated regularly with standards that are traceable Czech national standards.

Results of Czech Republic:

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U (k=2)
[m^3/h]	[Pa]	[°C]	[Pa]	[%]	[%]
1000	95335	21.63	844	0.08	0.25
800	95470	21.63	537	0.12	0.25
650	95545	21.62	369	0.12	0.25
450	95646	21.67	167	0.18	0.25
350	95672	21.68	94	0.20	0.25
250	95693	21.71	40	0.21	0.25
160	95707	21.71	22	0.25	0.25
100	95710	21.72	-	0.27	0.25
50	95705	21.74	-	0.30	0.25
20	95707	21.79	-	0.05	0.25

4.11. Switzerland

Location:
Federal Institute of Metrology METAS
Laboratory Flow and Hydrometry, Lindenweg 50, CH-3003 Bern-Wabern

Description of the test facility which was used for the test:
The test facility is our 10 m^3 bell prover for air flow rates between 1 m3/h and 1000 m3/h and is used for calibration and verifications of gas meters. The bell prover generates air flow due to his weight by displacement and the flow rate is regulated by flap valves. During the displacement of the bell the position is continuously measured by a scale. As the volume of the bell is calibrated at different consecutive reference positions and the positions of the scale are recorded, the flow rate is determined by the volume passed through and the time elapsed.

Traceability of the standard meters and other measuring instruments which were used during the test including the recalibration interval of the meters

- *Calibration interval of the volume of the bell prover:* 5 years (**METAS gas laboratory**, volumetric method)
- *Calibration interval of the pressure sensors:* 18 months (**METAS pressure laboratory**)
- *Calibration interval of the temperature sensors:* 18 months (**METAS thermometry laboratory**)
- *Calibration interval of the humidity sensor:* 18 months (**METAS thermometry laboratory**)
- *Calibration interval of the time measure:* a synchronization of the signal is performed at the beginning of each measurement with the reference signal of the **METAS time & frequency laboratory**.

Test procedure
The reference flow rates at the DUT are adjusted by means of the positions of the flap valve. Once the reference flow rate reaches a steady state, 5 consecutive comparison measurements between the bell prover and the DUT are performed.
The generated air flow is measured as volume flow by the bell prover, which is then transformed in mass flow by taking into account the pressure, the temperature and the humidity of the air at in the bell prover. The mass flow is considered to be constant along the pipes. Therefore the mass flow is converted back into volume flow at the DUT with respect to the pressure, the temperature and the humidity of the air at this position.

Results of Switzerland:

Flow rate of the transfer standard (m3/h)	Absolute pressure in the transfer standard (hPa)	Temperature in the transfer standard (°C)	Pressure loss of the transfer standard (hPa)	Error of the transfer standard (%)	Expanded uncertainty of measurement U (k=2) (%)
1000	960.962	20.787	6.780	0.12	0.12
800	962.341	20.834	4.380	0.11	0.12
650	963.285	20.863	2.900	0.13	0.12
450	973.924	20.827	1.440	0.17	0.12
350	974.265	20.850	0.900	0.18	0.12
250	975.162	20.852	0.470	0.18	0.12
160	975.405	20.858	0.220	0.21	0.12
100	975.629	20.866	0.100	0.22	0.12
50	976.452	20.910	0.050	0.20	0.12
20	979.187	20.942	0.030	0.10	0.12

4.12. Bosnia and Herzegovina

Location:
SARAJEVOGAS, LABORATORIJ ZA ISPITIVANJE I KALIBRACIJU MJERNIH INSTRUMENATA ZA GAS
Rajlovacka st., 71000 Sarajevo
Bosnia and Herzegovina

This laboratory is a subcontractor of Institute of Metrology of Bosnia and Herzegovina (IMBIH).

The calibration was performed between 15.12.2014 and 29.12.2014.

Description of the test facility (*Figure 20*)

Range of flow rate:	(0.5 – 4000) m^3/h
Temperature:	(21 ± 2)°C
Working pressure:	atmospheric conditions
Uncertainty (k=2):	0.31 %

Figure 20 - Test bench in SARAJEVOGAS

Standard meters used are:

Country NMI	NMI standard	Flow range of comparison	Traceability
Bosnia-Herzegovina IBMH	Rotary gas meter G40	20 - 50 m3/h	Traceable to VSL
	Turbine gas meter G250	100 – 350 m3/h	
	Turbine gas meter G1000	450 - 1000 m3/h	

Test procedure

Test facility operates on the master meter principle where the meter under test (transfer standard) is located downstream from the standard meters. Ambient air is sucked by a fan and the flow rate is adjusted by regulation of the fan and electromotive valve. Testing procedure is controlled by software.

The calibration was performed at atmospheric conditions with air temperature of about 22°C. The absolute pressure was measured on the meters while the temperatures are measured downstream.

After reaching the stable flow rate, the single tests lasted minimum 200 seconds. Tests at each of the calibration flow rates were repeated three times.

The error of the meter is calculated after correction of the volume indicated by master meter to the pressure and temperature conditions of the meter under test.

The calibration was performed with three standards/master meters: Rotary gas meter G40 and Turbine gas meters G250 and G1000.

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
995.83	95460	21.93	852	0.30	0.29
800.40	95693	21.84	528	0.28	0.29
651.00	95848	21.83	347	0.26	0.29
452.39	94243	21.88	162	0.22	0.29
349.77	94959	21.90	97	0.23	0.29
251.65	95496	21.92	49	0.24	0.29
159.54	95867	21.95	17	0.24	0.29
100.09	96023	21.99	-	0.23	0.29
50.23	95831	22.02	-	0.17	0.30
20.02	96079	22.05	-	0.27	0.31

4.13. Turkey

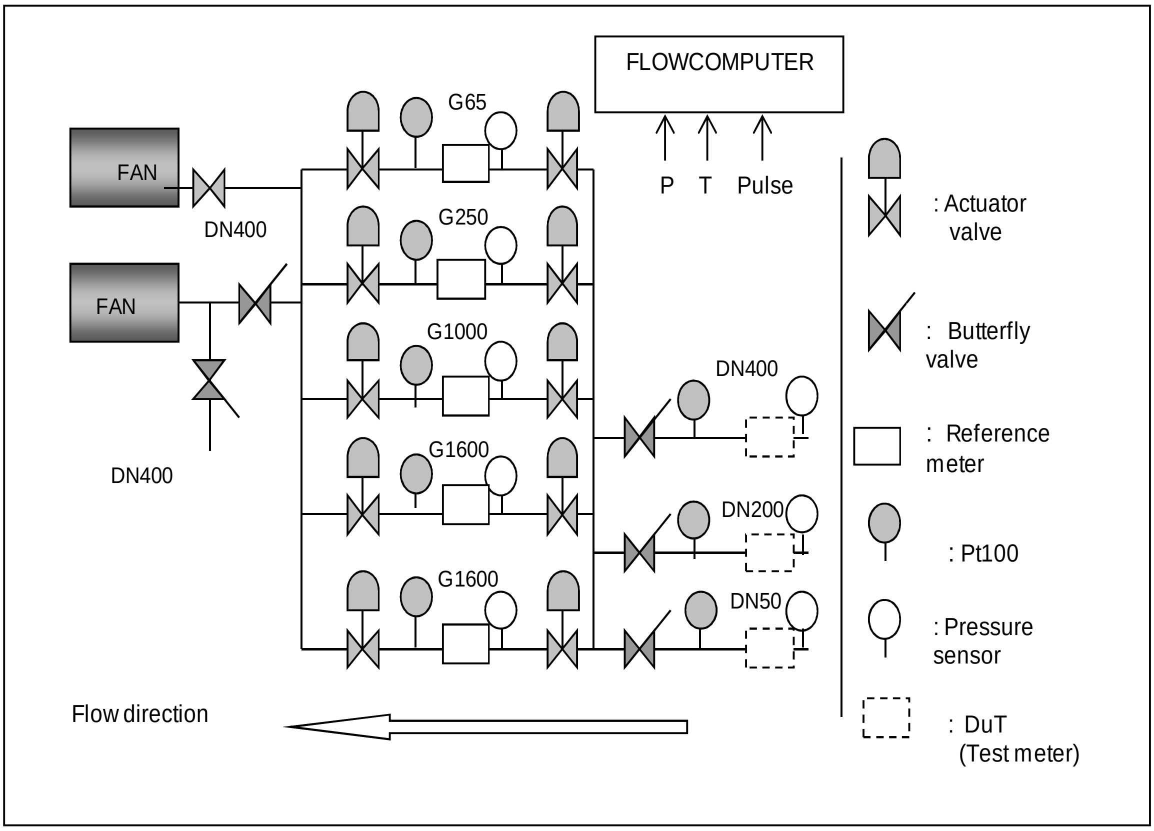
Location:
TÜBİTAK UME Gas Flow Laboratory
TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr.Zeki Acar Cad. No:141470
Gebze / KOCAELİ, TURKEY

Calibration Method and Procedure
The calibration of rotary piston gas meter IRM-3-DUO G650 was performed at TÜBİTAK UME Gas Flow Laboratory using UME Medium Flow Test Rig reference standard. This test rig has five reference turbine meters of different sizes for measuring 10 m^3/h to 6600 m^3/h air flow at atmospheric pressure with an uncertainty of 0.45% (k=2).
The traceability of the reference turbine flow meters of the test rig are connected to the Bell Prover of TÜBİTAK UME the primary reference standard through a stepwise calibration method. The recalibration interval of the test rig is three years.
The calibration is realized by comparing the flow rates indicated by reference turbine gas meters with the device under test by measuring a displaced volume and flow rate passes through the flowmeters at constant pressure and temperature.

The calibration procedure is as fallows;

1. Depending on the diameter of the connection of the meter the required connectors are selected or manufactured if necessary and connected to the system as shown in *Figure 21*.
2. Leakage test is performed.
3. The reference gas meter appropriate for the flow range is selected, and the automatic and manual valves on the working line are opened.
4. The Fan Frequency Control Unit (0-50 Hz) is set to ± 3% of the required flow value.
5. Five measurements were performed for each flow rate. A single measurement takes 4 minutes. Measured values (pulse, time, temperature, pressure) of the test gas meter and the reference gas meter are recorded from the flow computer. Mean values of the measurements are given in table with results.

Figure 21 - Medium flow test rig in TÜBİTAK UME



Results of TÜBİTAK UME

Flow rate in the meter	Absolute pressure in the meter	Temperature in the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
(m3/h)	(Pa)	(°C)	(Pa)	(%)	(%)
1000	994.08	20.92	980	0.34	0.46
800	995.77	21.07	680	0.37	0.46
650	996.73	21.13	450	0.42	0.46
450	997.61	21.10	210	0.45	0.46
350	998.07	21.36	130	0.49	0.46
250	999.20	20.83	65	0.54	0.46
160	999.37	20.93	28	0.64	0.46
100	999.49	20.67	13	0.74	0.46
50	999.73	20.80	4	0.83	0.46
20	999.76	20.97	1	0.90	0.46

5. Stability of the meter and the dependency of laboratories

During the project the rotary piston gas meter G650 was tested three times in the pilot laboratory (CMI). Obtained results are mentioned down.

flow rate (m^3/h)	error of the meter 25.3.2014	error of the meter 5.11.2014	error of the meter 26.3.2015	maximum difference
(m^3/h)	(%)	(%)	(%)	(%)
1000	0.08	0.05	0.11	0.06
800	0.12	0.10	0.18	0.08
650	0.12	0.09	0.16	0.07
450	0.18	0.16	0.22	0.06
350	0.20	0.18	0.23	0.05
250	0.21	0.19	0.23	0.04
160	0.25	0.23	0.28	0.05
100	0.27	0.27	0.30	0.04
50	0.30	0.32	0.32	0.02
20	0.05	0.11	0.13	0.08

The estimated standard uncertainty caused by the stability (reproducibility) of the rotary piston gas meter is approximately U_{tm}=0.048 %. In this case the uniform distribution between minimal value and maximal value is assumed.

In this project there were 5 independent laboratories:
Germany, Netherlands, Poland, Switzerland, Turkey

In this project there were 5 laboratories traceable to Netherlands (VSL):
Austria, Hungary, Denmark, Slovak Republic, Bosnia and Herzegovina

In this project there were 3 laboratories traceable to Germany (PTB):
Spain, Czech Republic, Lithuania

6. Determination of the reference values in determined flow rates

6.1. Description of the method

The reference value was determined in each flow rate separately. The method of determination of the reference value in each flow rate corresponds to the procedure A presented by M.G.Cox[2)]. Only results from independent laboratories were taken into account for the determination of the key comparison reference value (KCRV) and of the uncertainty of the key comparison reference value. Then the results from dependent laboratories were compared with the key comparison reference value and with the uncertainty of the key comparison reference value.

6.1.1. The determination of the Key Comparison Reference Value (KCRV) and its uncertainty

The reference value y was calculated as weighted mean error (WME):

$$y = \frac{\frac{x_1}{u_{x1}^2} + \frac{x_2}{u_{x2}^2} + \ldots\ldots\ldots \frac{x_n}{u_{xn}^2}}{\frac{1}{u_{x1}^2} + \frac{1}{u_{x2}^2} + \ldots\ldots\ldots \frac{1}{u_{xn}^2}} , \qquad [4]$$

where $x_1, x_2, \ldots\ldots x_n$ are errors of the meter in one flow rate in different independent laboratories $1,2, \ldots\ldots n$

$u_{x1}, u_{x2}, \ldots\ldots u_{xn}$ are standard uncertainties (not expanded) of the error in different independent laboratories $1,2, \ldots\ldots n$ including the uncertainty caused by stability of the meter

The standard uncertainties (not expanded) of the error in different laboratories $u_{x1}, u_{x2}, \ldots\ldots u_{xn}$ (equation [4]) include the stability of the meter. These uncertainties were calculated by

$$u_{xi} = \sqrt{\left(\frac{U_{xi\_lab}}{2}\right)^2 + \left(\frac{U_{tm}}{2}\right)^2} \qquad [5]$$

where U_{xi_lab} is the expanded uncertainty (k=2) determined by laboratory i and presented in results of laboratory i

U_{tm} is estimated standard uncertainty caused by the stability (reproducibility) of the rotary piston gas meter (see chapter 5)

The standard uncertainty of the reference value u_y is given by

$$\frac{1}{u_y^2} = \frac{1}{u_{x1}^2} + \frac{1}{u_{x2}^2} + \ldots\ldots\ldots \frac{1}{u_{xn}^2} \qquad [6]$$

[2)] Cox M.G., *Evaluation of key comparison data*, Metrologia, 2002, **39**, 589-595

The expanded uncertainty of the reference value *U(y)* is

$$U(y) = 2.u_y \qquad [7]$$

The chi-squared test for consistency check was performed using values of errors of the meter in each flow rate. At first the chi-squared value χ^2_{obs} was calculated by

$$\chi^2_{obs} = \frac{(x_1 - y)^2}{u^2_{x1}} + \frac{(x_2 - y)^2}{u^2_{x2}} + ... \frac{(x_n - y)^2}{u^2_{xn}} \qquad [8]$$

The degrees of freedom ν were assigned

$$\nu = n - 1 \qquad [9]$$

where n is number of evaluated laboratories.

The consistency check was failing if

$$Pr\{\chi^2_\nu > \chi^2_{obs}\} < 0{,}05 \qquad [10]$$

(The function *CHIINV(0,05;ν)* in MS Excel was used. The consistency check was failing if *CHIINV(0,05; ν)*< χ^2_{obs})

If the consistency check did not fail then y was accepted as the key comparison reference value x_{ref} and *U(y)* was accepted as the expanded uncertainty of the key comparison reference value $U(x_{ref})$.

If the consistency check failed then the laboratory with the highest value of $\frac{(x_i - y)^2}{u^2_{xi}}$ was excluded for the next round of evaluation and the new reference value y (WME), the new standard uncertainty of the reference value u_y and the chi-squared value χ^2_{obs} were calculated again without the values of excluded laboratory. The consistency check was calculated again, too. This procedure was repeated till the consistency check passed.

6.1.2. The determination of the differences "Lab to KCRV" and "Lab to Lab" as well as their uncertainties and Degrees of Equivalence

When the KCRV was determined, the differences between the participating laboratories and the KCRV were calculated according to

$$di = x_i - x_{ref} \qquad [11]$$

$$dij = x_i - x_j \qquad [12]$$

Based on these differences, the **D**egree **o**f **E**quivalence (*DoE*) was calculated according to:

$$Ei = \left| \frac{di}{U(di)} \right| \qquad [13]$$

and $$Eij = \left| \frac{dij}{U(dij)} \right| \text{, respectively.} \qquad [14]$$

The *DoE* is a measure for the equivalence of the results of any laboratory with the KCRV or with any other laboratory, respectively:

- The results of a laboratory is ***equivalent (passed) if Ei or Eij≤1.***
- The laboratory was determined as ***not equivalent (failed) if Ei or Eij >1.2***.
- For values of *DoE* in the range ***1 < Ei or Eij ≤ 1.2*** we define "**warning level**" were actions to check is recommended to the laboratory.

  The reason for such "warning level" is that we have to consider the confidence in the determination of the uncertainties (for the results of labs as well the KCRV). Conventionally we work at a 95% confidence level. Therefore in some comparisons a range up to *E < 1.5* is used for these "warnings"[3]. This is a reasonable value where stochastic influences dominate the uncertainty budgets. In the case of comparisons for gas flow, the smaller value 1.2 was chosen, which reflects the dominance of non-stochastic parts of uncertainty compared to the stochastic parts. (The reproducibility is usually much better than the total uncertainty of a laboratory). [4]

The calculation of the *DoE* needs the information about the uncertainty of the differences *di* and *dij* (equations [11] and [12]). To make statements about this, let us consider first the general problem of the difference of two values x_1 and x_2. If we look to the pure propagation of (standard) uncertainty we find:

$$u_{x_1-x_2}^2 = \begin{pmatrix} \frac{\partial(x_1-x_2)}{\partial x_1} & \frac{\partial(x_1-x_2)}{\partial x_2} \end{pmatrix} \begin{pmatrix} u_1^2 & \text{cov} \\ \text{cov} & u_2^2 \end{pmatrix} \begin{pmatrix} \frac{\partial(x_1-x_2)}{\partial x_1} \\ \frac{\partial(x_1-x_2)}{\partial x_2} \end{pmatrix} = u_1^2 + u_2^2 - 2.\text{cov} \qquad [15]$$

Simply spoken, the (standard) uncertainty of the difference is the quadratic sum of the uncertainties of the inputs (u_1 and u_2) subtracting twice the covariance (*cov*) between the two input values.

Therefore we have to look to the different cases in this comparison:

A) <u>Differences to the KCRV</u>

A1) *Independent laboratories with contribution to the KCRV*

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[3] C. Ullner et al., *Special features in proficiency tests of mechanical testing laboratories*, and P. Robouch et al., *The „Naji Plot", a simple graphical tool for the evaluation of inter-laboratory comparisons*,

[4] D.Dopheide, B.Mickan, R.Kramer, H.-J.Hotze, J.-P.Vallet, M.R.Harris, Jiunn-Haur Shaw, Kyung-Am Park, *CIPM Key Comparisons for Compressed Air and Nitrogen, CCM.FF-5.b – Final Report*, 07/09/2006 http://kcdb.bipm.org/appendixB/appbresults/ccm.ff-k5.b/ccm.ff-k5.b_final_report.pdf

The covariance between the result of a laboratory (with contribution to the KCRV) and the KCRV is the variance of the KCRV itself. [5)]

=> $u(di) = \sqrt{u_{xi}^2 + u_{xref}^2 - 2.u_{xref}^2} = \sqrt{u_{xi}^2 - u_{xref}^2}$ [16]

A2) *Independent laboratories without contribution to the KCRV*

There is no covariance between the result of a laboratory without contribution and the KCRV.

=> $u(di) = \sqrt{u_{xi}^2 + u_{xref}^2}$ [17]

A3) *Laboratories with traceability to a laboratory contributing to the KCRV*

In this case we have covariance between the laboratory and the KCRV because the laboratory is linked to the KCRV via the source of traceability. Although we have no detailed information about it, we can determine a conservative estimation of an upper limit of this covariance. The upper limit is determined for the theoretical case if we have no additional stochastic influence in the traceability of the lab from its source (which is the lab contributing to the KCRV). Then the results of the lab considered here would be strongly correlated with the results of the laboratory contributing to the KCRV (correlation coefficient = 1) and there would be the same covariance to the KCRV as in case A1. In any case of additional uncertainty caused stochastically the correlation and consequently the covariance is smaller.

=> $u(di) = \sqrt{u_{xi}^2 + u_{xref}^2 - 2u_{xref}^2} = \sqrt{u_{xi}^2 - u_{xref}^2}$ [18]

B) <u>Differences Lab to Lab</u>

B1) *Independent laboratories*

There is no covariance between the results of two independent laboratory *i* and *j*

=> $u(dij) = \sqrt{u_{xi}^2 + u_{xj}^2}$ [19]

B2) *Dependent laboratories with common source of traceability*

In the case of two labs *i* and *j* with a common source of traceability we will find again a covariance between these labs which is caused by the common source. In our case the common source is another laboratory from which the traceabilities of both labs are derived. Again we can determine a conservative upper limit of the covariance for the same reason as in A3 as cov = $u^2_{SourceLab}$.

=> $u(dij) = \sqrt{u_{xi}^2 + u_{xj}^2 - 2.u_{SourceLab}^2}$ [20]

The equations from [16] to [20] use the standard uncertainties (k = 1). The expanded uncertainties *U(di)* and *U(dij)* (see equations [13],[14]) are determined by

$$U(di) = 2.u(di) \quad [21]$$
$$U(dij) = 2.u(dij) \quad [22]$$

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5) Cox M.G., *Evaluation of key comparison data*, Metrologia, 2002, **39**, 589-595

6.2. Flow rate 1000 m^3/h

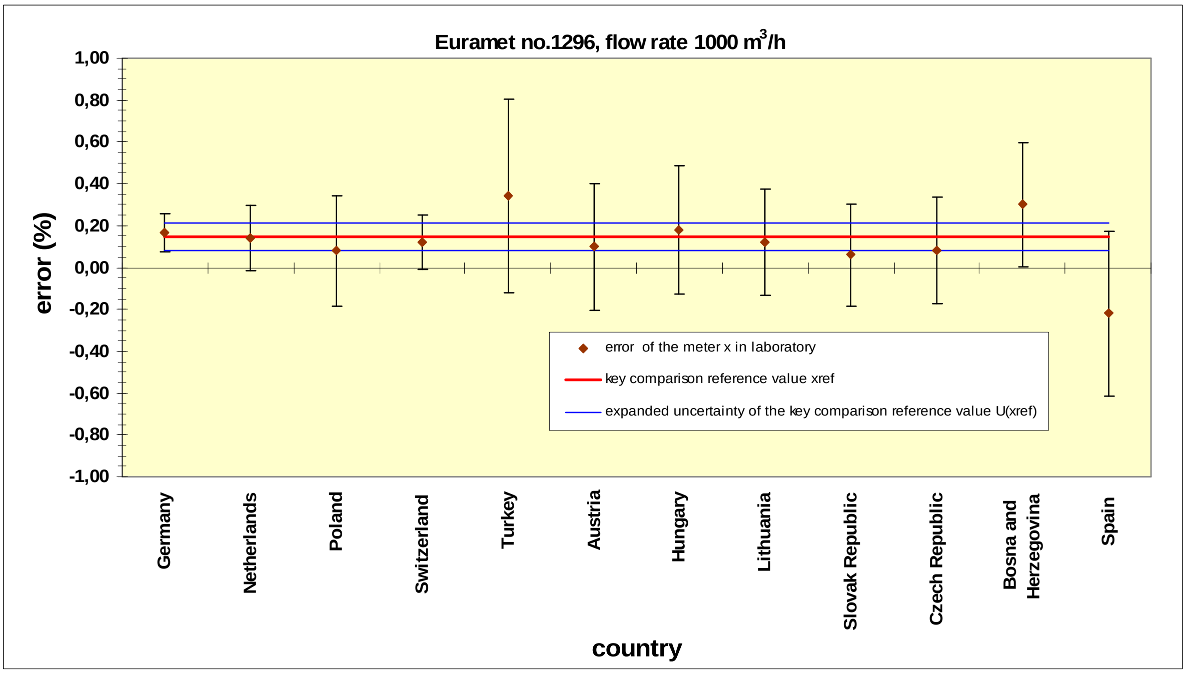
The first and last round of evaluation in 1000 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0,167	0,08	0,09335	0,158	458,9885	76,651
Netherlands	0,140	0,15	0,15753	0,012	161,1940	22,567
Poland	0,080	0,26	0,26441	0,268	57,2125	4,577
Switzerland	0,120	0,12	0,12929	0,194	239,3087	28,717
Turkey	0,340	0,46	0,46251	0,686	18,6990	6,358

WME = y = 0.148460072
U(y)= 0.065392912
CHIINV 9.487729037
χ^2_{obs} = 1.173

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.17	0.08	0.09	0.02	0.067	0.28
Netherlands	0.14	0.15	0.16	-0.01	0.143	0.06
Poland	0.08	0.26	0.26	-0.07	0.256	0.27
Switzerland	0.12	0.12	0.13	-0.03	0.112	0.26
Turkey	0.34	0.46	0.46	0.19	0.458	0.42
Austria	0.10	0.30	0.30	-0.05	0.297	0.16
Hungary	0.18	0.30	0.30	0.03	0.297	0.11
Denmark	-	-	-	-	-	-
Lithuania	0.12	0.25	0.25	-0.03	0.246	0.12
Slovak Republic	0.06	0.24	0.24	-0.09	0.236	0.38
Czech Republic	0.08	0.25	0.25	-0.07	0.246	0.28
Bosnia and Herzegovina	0.30	0.29	0.29	0.15	0.287	0.53
Spain	-0.22	0.39	0.39	-0.37	0.387	0.95



6.3. Flow rate 800 m^3/h

The first and last round of evaluation in 800 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i-y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0,10	0,08	0,09	0,023	450,66	43,26
Netherlands	0,09	0,15	0,16	0,028	161,19	14,51
Poland	0,08	0,27	0,27	0,029	53,18	4,25
Switzerland	0,11	0,12	0,13	0,011	239,31	26,32
Turkey	0,37	0,46	0,46	1,331	18,70	6,92

WME = y = 0,10321069

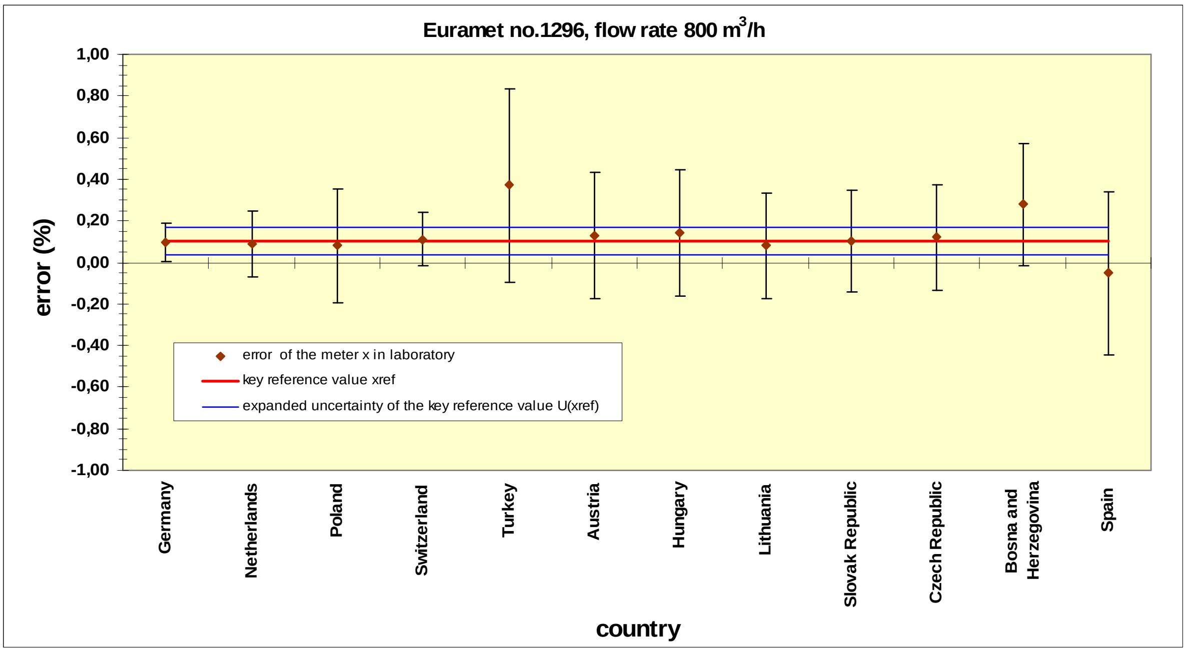
U(y)= 0,065829176

CHIINV 9,487729037

χ^2_{obs} = 1,4222

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.10	0.08	0.09421	-0.0072	0.067	0.11
Netherlands	0.09	0.15	0.15753	-0.0132	0.143	0.09
Poland	0.08	0.27	0.27425	-0.0232	0.266	0.09
Switzerland	0.11	0.12	0.12929	0.0068	0.111	0.06
Turkey	0.37	0.46	0.46251	0.2668	0.458	0.58
Austria	0.13	0.30	0.30383	0.0268	0.297	0.09
Hungary	0.14	0.30	0.30383	0.0368	0.297	0.12
Denmark	-	-	-	-	-	-
Lithuania	0.08	0.25	0.25459	-0.0232	0.246	0.09
Slovak Republic	0.10	0.24	0.24478	-0.0032	0.236	0.01
Czech Republic	0.12	0.25	0.25459	0.0168	0.246	0.07
Bosna and Herzegovina	0.28	0.29	0.29396	0.1768	0.286	0.62
Spain	-0.05	0.39	0.39296	-0.1532	0.387	0.40



6.4. Flow rate 650 m^3/h

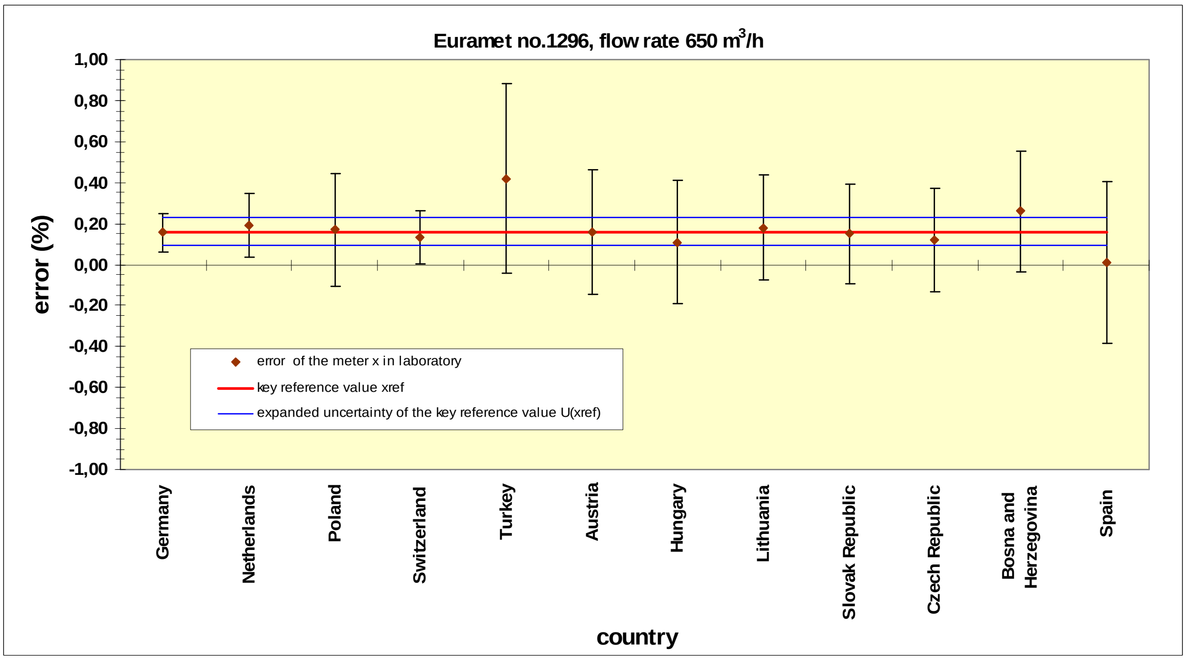
The first and last round of evaluation in 650 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i-y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.16	0.08	0.093353	0.013	458.99	71.60
Netherlands	0.19	0.15	0.157527	0.133	161.19	30.63
Poland	0.17	0.27	0.274253	0.004	53.18	9.04
Switzerland	0.13	0.12	0.129286	0.235	239.31	31.11
Turkey	0.42	0.46	0.462509	1.251	18.70	7.85

WME = y = 0.161303632
U(y)= 0.065534287
CHIINV 9.487729037
χ^2_{obs} = 1.6356

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.16	0.08	0.09	-0.0053	0.066	0.08
Netherlands	0.19	0.15	0.16	0.0287	0.143	0.20
Poland	0.17	0.27	0.27	0.0087	0.266	0.03
Switzerland	0.13	0.12	0.13	-0.0313	0.111	0.28
Turkey	0.42	0.46	0.46	0.2587	0.458	0.57
Austria	0.16	0.30	0.30	-0.0013	0.297	0.00
Hungary	0.11	0.30	0.30	-0.0513	0.297	0.17
Denmark	-	-	-	-	-	-
Lithuania	0.18	0.25	0.25	0.0187	0.246	0.08
Slovak Republic	0.15	0.24	0.24	-0.0113	0.236	0.05
Czech Republic	0.12	0.25	0.25	-0.0413	0.246	0.17
Bosnia and Herzegovina	0.26	0.29	0.29	0.0987	0.287	0.34
Spain	0.01	0.39	0.39	-0.1513	0.387	0.39



6.5. Flow rate 450 m^3/h

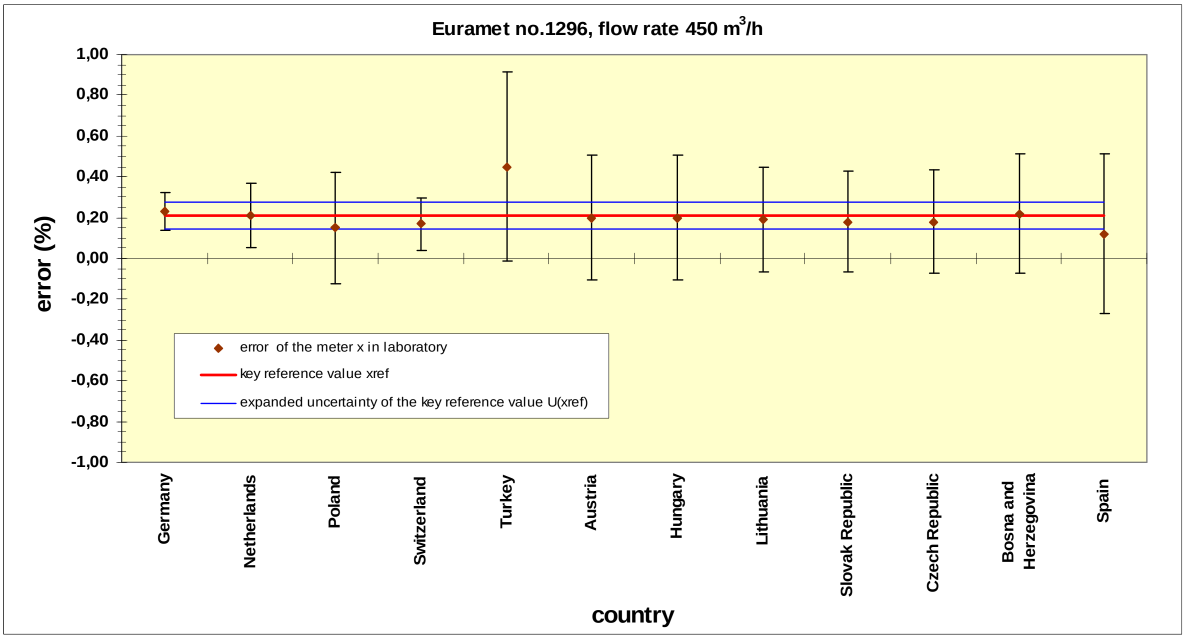
The first and last round of evaluation in 450 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.0933532	0.157	458.99	105.11
Netherlands	0.21	0.15	0.1575272	0.000	161.19	33.85
Poland	0.15	0.27	0.2742532	0.195	53.18	7.98
Switzerland	0.17	0.12	0.1292858	0.392	239.31	40.68
Turkey	0.45	0.46	0.4625093	1.073	18.70	8.41

WME = y = 0.210478158
U(y)= 0.065534287
CHIINV 9.487729037
χ^2_{obs} = 1.8169

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.09	0.0185	0.066	0.28
Netherlands	0.21	0.15	0.16	-0.0005	0.143	0.00
Poland	0.15	0.27	0.27	-0.0605	0.266	0.23
Switzerland	0.17	0.12	0.13	-0.0405	0.111	0.36
Turkey	0.45	0.46	0.46	0.2395	0.458	0.52
Austria	0.20	0.30	0.30	-0.0105	0.297	0.04
Hungary	0.20	0.30	0.30	-0.0105	0.297	0.04
Denmark	-	-	-	-	-	-
Lithuania	0.19	0.25	0.25	-0.0205	0.246	0.08
Slovak Republic	0.18	0.24	0.24	-0.0305	0.236	0.13
Czech Republic	0.18	0.25	0.25	-0.0305	0.246	0.12
Bosna and Herzegovina	0.22	0.29	0.29	0.0095	0.287	0.03
Spain	0.12	0.39	0.39	-0.0905	0.387	0.23



6.6. Flow rate 350m^3/h

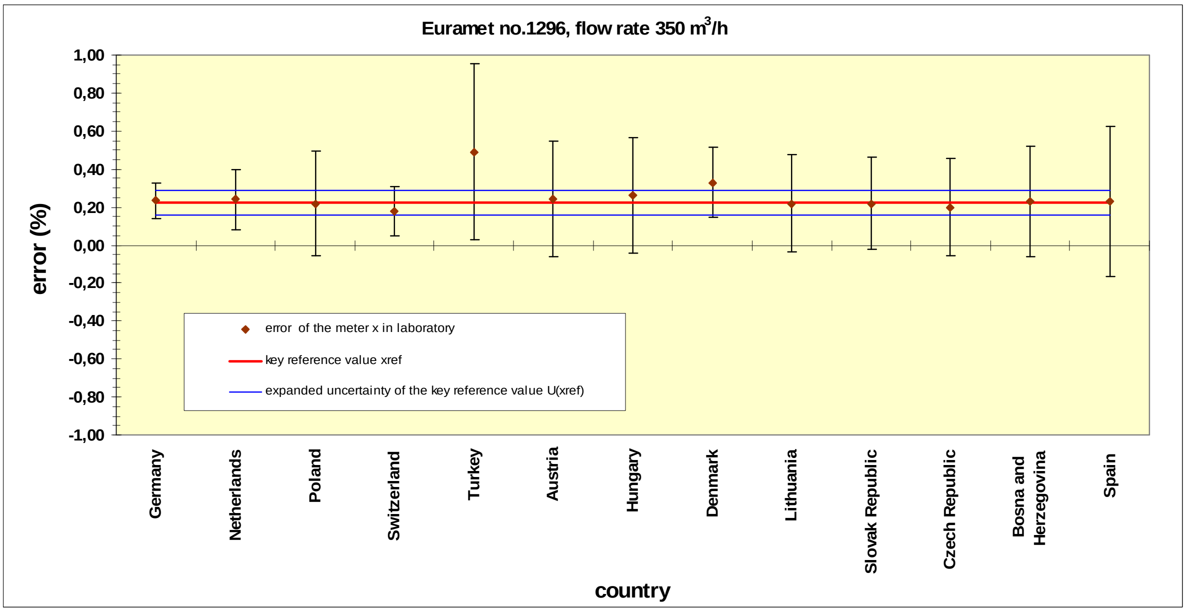
The first and last round of evaluation in 350 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.09335	0.033	458.99	107.40
Netherlands	0.24	0.15	0.15753	0.034	161.19	38.69
Poland	0.22	0.27	0.27425	0.002	53.18	11.70
Switzerland	0.18	0.12	0.12929	0.496	239.31	43.08
Turkey	0.49	0.46	0.46251	1.308	18.70	9.16

WME = y = 0.225503833
U(y)= 0.065534287
CHIINV 9.487729037
χ^2_{obs} = 1.8723

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.09	0.0085	0.066	0.13
Netherlands	0.24	0.15	0.16	0.0145	0.143	0.10
Poland	0.22	0.27	0.27	-0.0055	0.266	0.02
Switzerland	0.18	0.12	0.13	-0.0455	0.111	0.41
Turkey	0.49	0.46	0.46	0.2645	0.458	0.58
Austria	0.24	0.30	0.30	0.0145	0.297	0.05
Hungary	0.26	0.30	0.30	0.0345	0.297	0.12
Denmark	0.33	0.18	0.19	0.1045	0.174	0.60
Lithuania	0.22	0.25	0.25	-0.0055	0.246	0.02
Slovak Republic	0.22	0.24	0.24	-0.0055	0.236	0.02
Czech Republic	0.20	0.25	0.25	-0.0255	0.246	0.10
Bosnia and Herzegovina	0.23	0.29	0.29	0.0045	0.287	0.02
Spain	0.23	0.39	0.39	0.0045	0.387	0.01



6.7. Flow rate 250 m^3/h

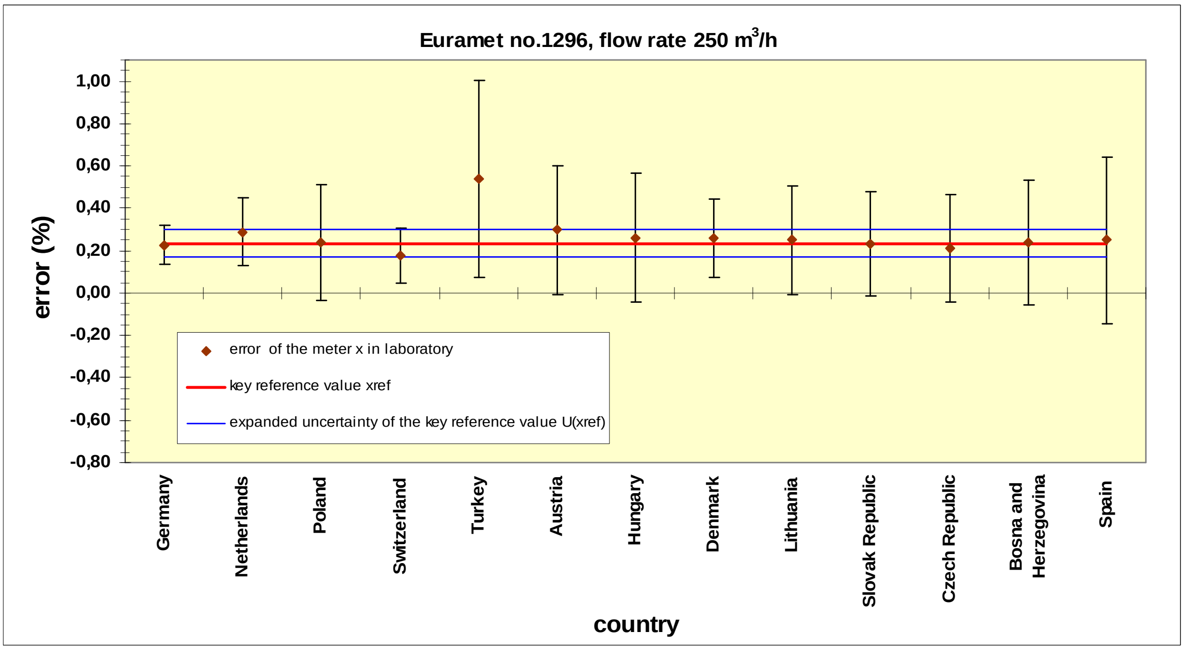
The first and last round of evaluation in 250 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.09335	0.016	458.99	104.19
Netherlands	0.29	0.15	0.15753	0.526	161.19	46.75
Poland	0.24	0.27	0.27425	0.003	53.18	12.76
Switzerland	0.18	0.12	0.12929	0.669	239.31	43.08
Turkey	0.54	0.46	0.46251	1.764	18.70	10.10

WME = y = 0.232853591
U(y)= 0.065534287
CHIINV 9.487729037
χ^2_{obs} = 2.9774

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.23	0.08	0.093	-0.0059	0.066	0.09
Netherlands	0.29	0.15	0.158	0.0571	0.143	0.40
Poland	0.24	0.27	0.274	0.0071	0.266	0.03
Switzerland	0.18	0.12	0.129	-0.0529	0.111	0.47
Turkey	0.54	0.46	0.463	0.3071	0.458	0.67
Austria	0.30	0.30	0.304	0.0671	0.297	0.23
Hungary	0.26	0.30	0.304	0.0271	0.297	0.09
Denmark	0.26	0.18	0.186	0.0271	0.174	0.16
Lithuania	0.25	0.25	0.255	0.0171	0.246	0.07
Slovak Republic	0.23	0.24	0.245	-0.0029	0.236	0.01
Czech Republic	0.21	0.25	0.255	-0.0229	0.246	0.09
Bosnia and Herzegovina	0.24	0.29	0.294	0.0071	0.287	0.02
Spain	0.25	0.39	0.393	0.0171	0.387	0.04



6.8. Flow rate 160 m³/h

The first and last round of evaluation in 160 m³/h:

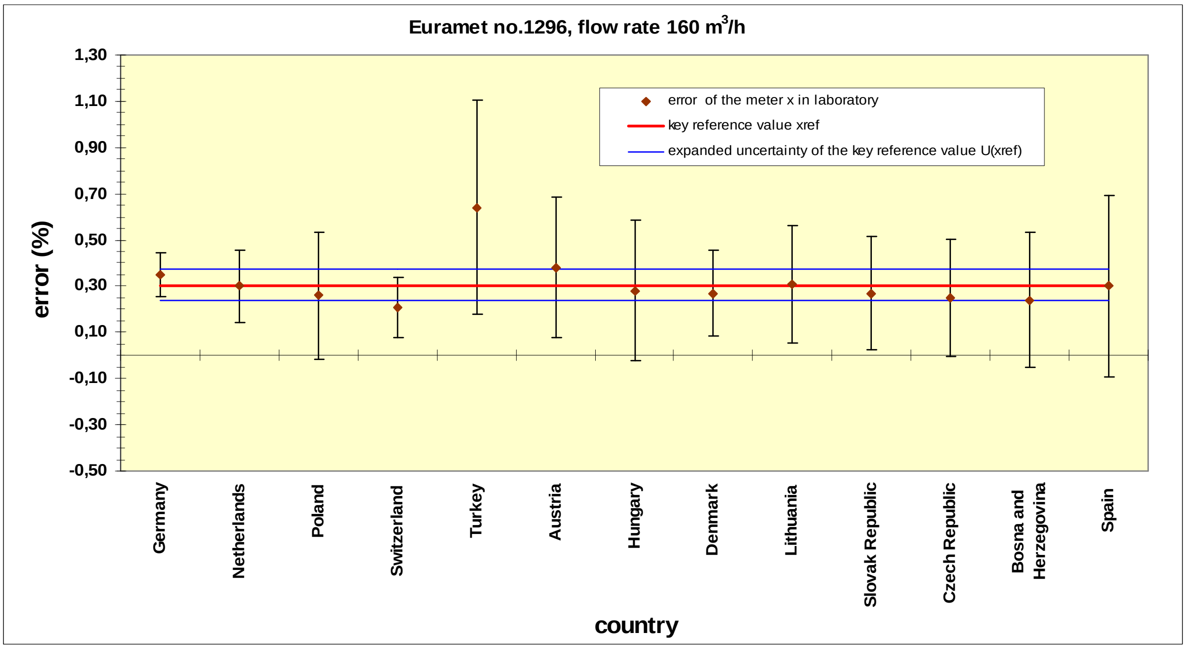
Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.35	0.08	0.093353	0.846	458.99	159.73
Netherlands	0.30	0.15	0.157527	0.004	161.19	48.36
Poland	0.26	0.27	0.274253	0.108	53.18	13.83
Switzerland	0.21	0.12	0.129286	2.163	239.31	50.25
Turkey	0.64	0.46	0.462509	2.098	18.70	11.97

WME = y = 0.305072198
U(y)= 0.065534287
CHIINV 9.487729037

χ^2_{obs} = 5.2186

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.35	0.08	0.09	0.0429	0.066	0.65
Netherlands	0.30	0.15	0.16	-0.0051	0.143	0.04
Poland	0.26	0.27	0.27	-0.0451	0.266	0.17
Switzerland	0.21	0.12	0.13	-0.0951	0.111	0.85
Turkey	0.64	0.46	0.46	0.3349	0.458	0.73
Austria	0.38	0.30	0.30	0.0749	0.297	0.25
Hungary	0.28	0.30	0.30	-0.0251	0.297	0.08
Denmark	0.27	0.18	0.19	-0.0351	0.174	0.20
Lithuania	0.31	0.25	0.25	0.0049	0.246	0.02
Slovak Republic	0.27	0.24	0.24	-0.0351	0.236	0.15
Czech Republic	0.25	0.25	0.25	-0.0551	0.246	0.22
Bosnia and Herzegovina	0.24	0.29	0.29	-0.0651	0.287	0.23
Spain	0.30	0.39	0.39	-0.0051	0.387	0.01



6.9. Flow rate 100 m^3/h

The first and last round of evaluation in 100 m^3/h:

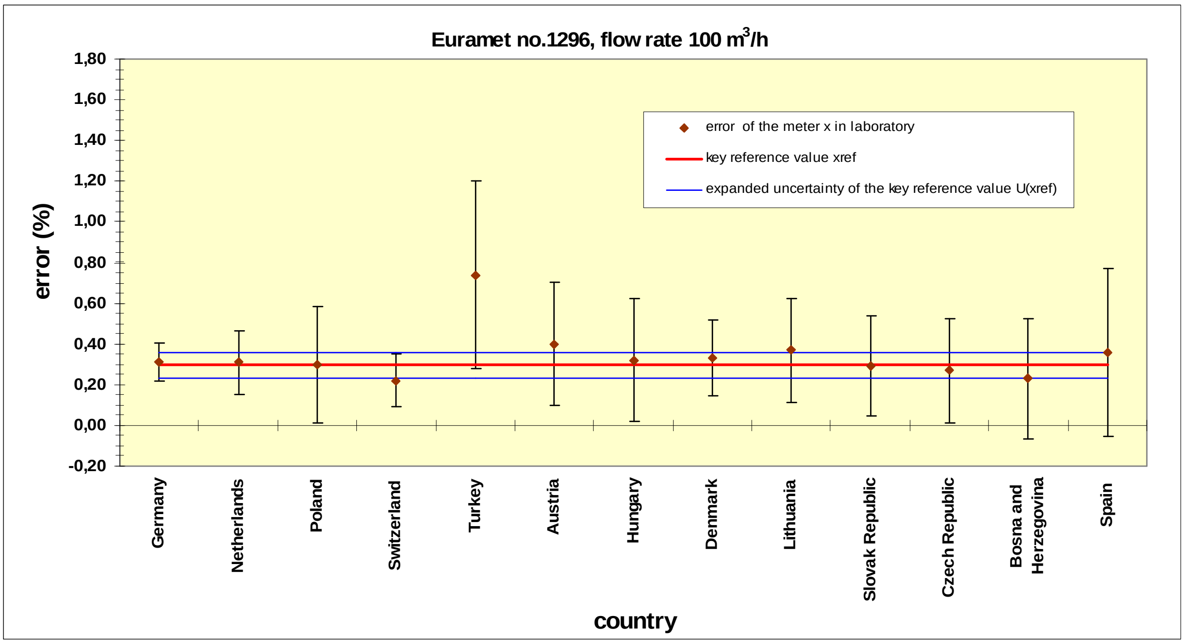
Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i-y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.31	0.08	0.093353	0.112	458.99	142.75
Netherlands	0.31	0.15	0.157527	0.034	161.19	49.97
Poland	0.30	0.28	0.284104	0.001	49.56	14.87
Switzerland	0.22	0.12	0.129286	1.361	239.31	52.65
Turkey	0.74	0.46	0.462509	3.696	18.70	13.84

WME = y = 0.295412216
U(y)= 0.065662152
CHIINV 9.487729037

χ^2_{obs} = 5.2038

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.31	0.08	0.093	0.0156	0.066	0.23
Netherlands	0.31	0.15	0.158	0.0146	0.143	0.10
Poland	0.30	0.28	0.284	0.0046	0.276	0.02
Switzerland	0.22	0.12	0.129	-0.0754	0.111	0.68
Turkey	0.74	0.46	0.463	0.4446	0.458	0.97
Austria	0.40	0.30	0.304	0.1046	0.297	0.35
Hungary	0.32	0.30	0.304	0.0246	0.297	0.08
Denmark	0.33	0.18	0.186	0.0346	0.174	0.20
Lithuania	0.37	0.25	0.255	0.0746	0.246	0.30
Slovak Republic	0.29	0.24	0.245	-0.0054	0.236	0.02
Czech Republic	0.27	0.25	0.255	-0.0254	0.246	0.10
Bosnia and Herzegovina	0.23	0.29	0.294	-0.0654	0.287	0.23
Spain	0.36	0.41	0.413	0.0646	0.408	0.16



6.10. Flow rate 50 m^3/h

The first and last round of evaluation in 50 m^3/h:

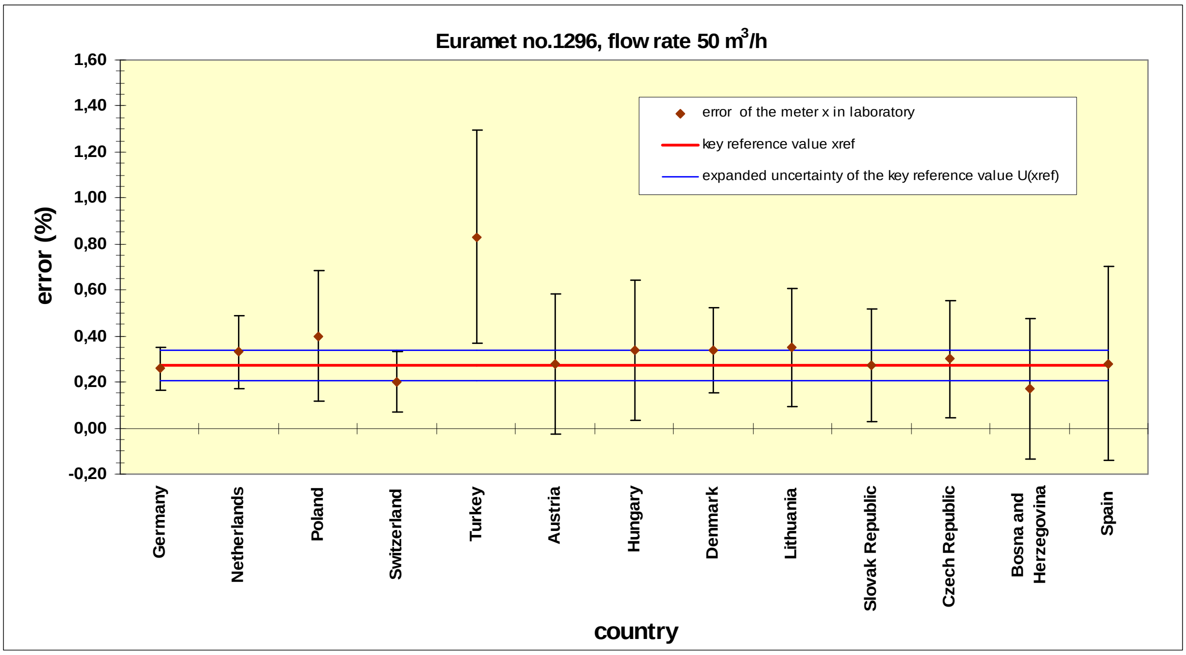
Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i-y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.26	0.080000	0.093	0.120	458.99	118.88
Netherlands	0.33	0.150000	0.158	0.485	161.19	53.19
Poland	0.40	0.280000	0.284	0.772	49.56	19.82
Switzerland	0.20	0.120000	0.129	1.352	239.31	47.86
Turkey	0.83	0.460000	0.463	5.756	18.70	15.52

WME = y = 0.275157713
U(y)= 0.065662152
CHIINV 9.487729037

χ^2_{obs} = 8.4853

The consistency check passed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.26	0.08	0.093	-0.0162	0.066	0.24
Netherlands	0.33	0.15	0.158	0.0548	0.143	0.38
Poland	0.40	0.28	0.284	0.1248	0.276	0.45
Switzerland	0.20	0.12	0.129	-0.0752	0.111	0.67
Turkey	0.83	0.46	0.463	0.5548	0.458	1.21
Austria	0.28	0.30	0.304	0.0048	0.297	0.02
Hungary	0.34	0.30	0.304	0.0648	0.297	0.22
Denmark	0.34	0.18	0.186	0.0648	0.174	0.37
Lithuania	0.35	0.25	0.255	0.0748	0.246	0.30
Slovak Republic	0.27	0.24	0.245	-0.0052	0.236	0.02
Czech Republic	0.30	0.25	0.255	0.0248	0.246	0.10
Bosnia and Herzegovina	0.17	0.30	0.304	-0.1052	0.297	0.35
Spain	0.28	0.42	0.423	0.0048	0.418	0.01



6.11. Flow rate 20 m^3/h

The first round of evaluation in 20 m^3/h:

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.04	0.08	0.093353	1.903	458.99	18.82
Netherlands	0.15	0.15	0.157527	0.321	161.19	24.18
Poland	0.35	0.33	0.333489	2.152	35.97	12.59
Switzerland	0.10	0.12	0.129286	0.007	239.31	23.93
Turkey	0.90	0.46	0.462509	11.807	18.70	16.83

WME = y = 0.105393181
U(y)= 0.066148451
CHIINV 9.487729037

χ^2_{obs} = 16.1894

The consistency check failed because CHIINV < χ^2_{obs}
The result of Turkey was excluded for the next round of evaluation.

The second and last round of evaluation in 20 m^3/h:

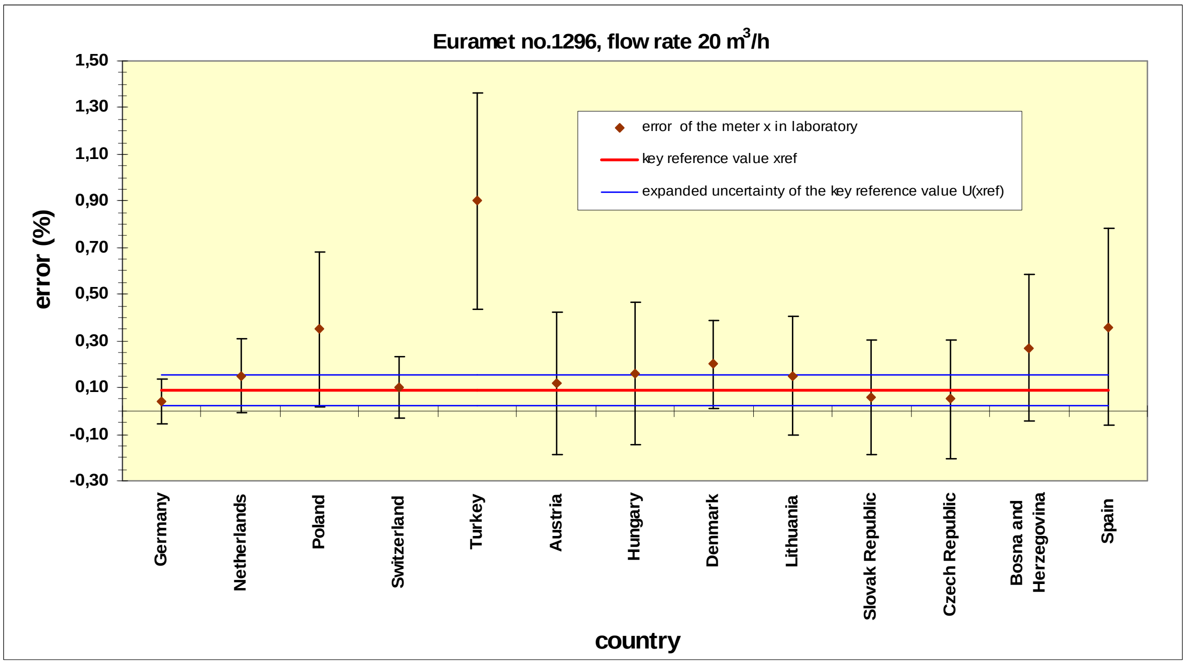
Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	*1/u^2*	*x*(1/u)^2*
	(%)	(%)	(%)			
Germany	0.04	0.08	0.093353	1.049	458.99	18.82
Netherlands	0.15	0.15	0.157527	0.604	161.19	24.18
Poland	0.35	0.33	0.333489	2.454	35.97	12.59
Switzerland	0.10	0.12	0.129286	0.030	239.31	23.93

WME = y = 0.088800125
U(y)= 0.066835541
CHIINV 7.814727764

χ^2_{obs} = 4.1363

The consistency check failed because CHIINV > χ^2_{obs}

Country	Error of the meter *x*	Uncertainty *U(k=2)*	Uncertainty +stability *U(k=2)*	*di*	*U(di)*	*Ei*
	(%)	(%)	(%)			
Germany	0.04	0.08	0.093353	-0.0478	0.065	0.73
Netherlands	0.15	0.15	0.157527	0.0612	0.143	0.43
Poland	0.35	0.33	0.333489	0.2612	0.327	0.80
Switzerland	0.10	0.12	0.129286	0.0112	0.111	0.10
Turkey	0.90	0.46	0.462509	0.8112	0.467	1.74
Austria	0.12	0.30	0.303834	0.0312	0.296	0.11
Hungary	0.16	0.30	0.303834	0.0712	0.296	0.24
Denmark	0.20	0.18	0.186319	0.1112	0.174	0.64
Lithuania	0.15	0.25	0.254588	0.0612	0.246	0.25
Slovak Republic	0.06	0.24	0.244775	-0.0288	0.235	0.12
Czech Republic	0.05	0.25	0.254588	-0.0388	0.246	0.16
Bosnia and Herzegovina	0.27	0.31	0.313711	0.1812	0.307	0.59
Spain	0.36	0.42	0.422747	0.2712	0.417	0.65

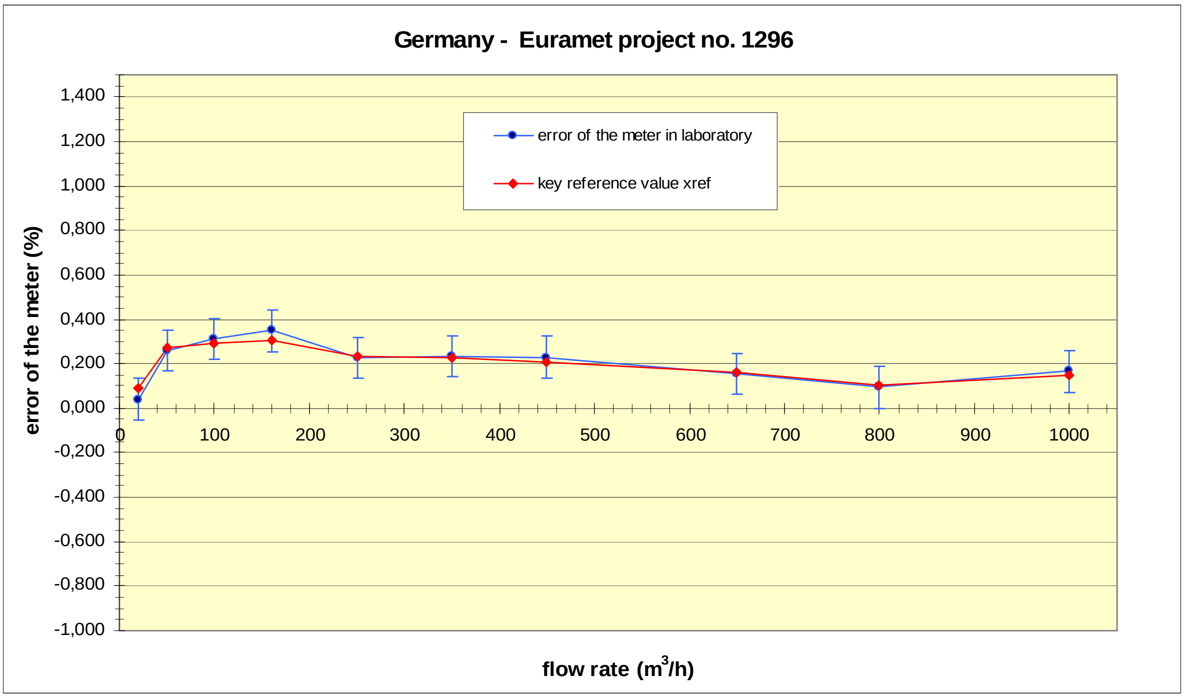

Euramet no.1296, flow rate 20 m3/h
error of the meter x in laboratory
key reference value xref
expanded uncertainty of the key reference value U(xref)
error (%)
1,50
1,30
1,10
0,90
0,70
0,50
0,30
0,10
-0,10
-0,30
Germany
Netherlands
Poland
Switzerland
Turkey
Austria
Hungary
Denmark
Lithuania
Slovak Republic
Czech Republic
Bosna and Herzegovina
Spain
country

7. Results

7.1. Independent laboratories

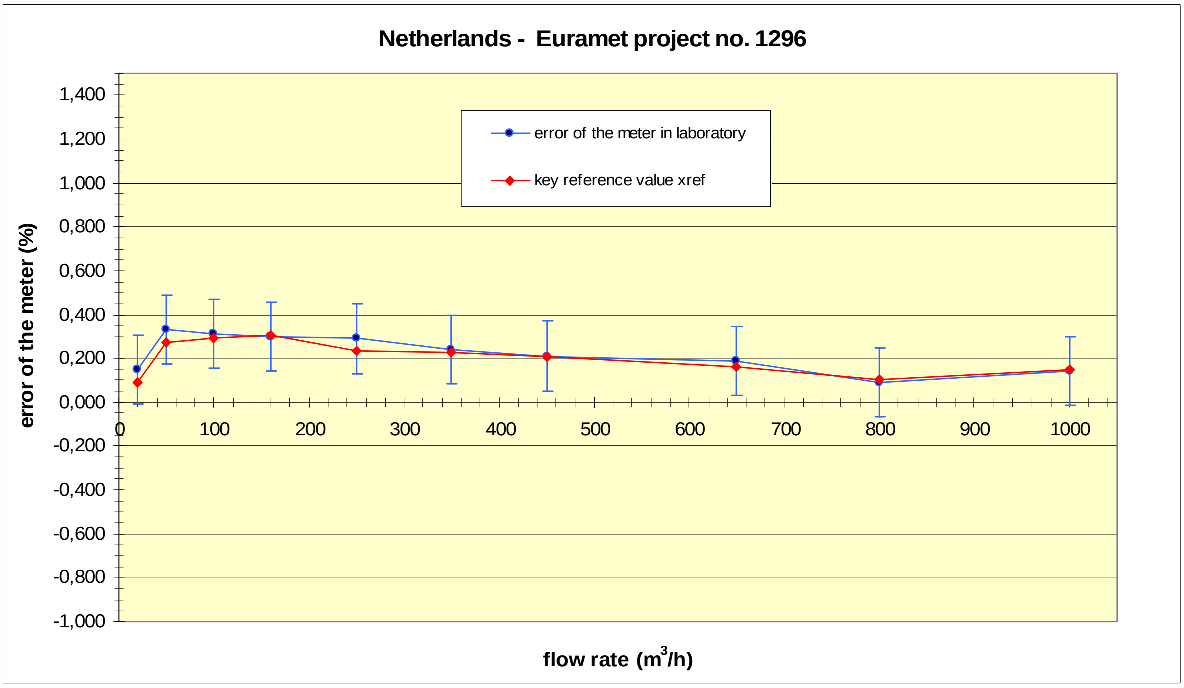
7.1.1. Germany

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	consistency check	di	Ei	result
m³/h	%	%	%	%	%	%				
1000	0.167	0.080	0.080	0.093	0.148	0.065	inside	0.02	0.28	passed
800	0.096	0.081	0.080	0.094	0.103	0.066	inside	-0.01	0.11	passed
650	0.156	0.080	0.080	0.093	0.161	0.066	inside	-0.01	0.08	passed
450	0.229	0.080	0.080	0.093	0.210	0.066	inside	0.02	0.28	passed
350	0.234	0.080	0.080	0.093	0.226	0.066	inside	0.01	0.13	passed
250	0.227	0.080	0.080	0.093	0.233	0.066	inside	-0.01	0.09	passed
160	0.348	0.080	0.080	0.093	0.305	0.066	inside	0.04	0.65	passed
100	0.311	0.080	0.080	0.093	0.295	0.066	inside	0.02	0.23	passed
50	0.259	0.080	0.080	0.093	0.275	0.066	inside	-0.02	0.24	passed
20	0.041	0.080	0.080	0.093	0.089	0.067	inside	-0.05	0.73	passed
							mean	**0.00**	**0.28**	**passed**



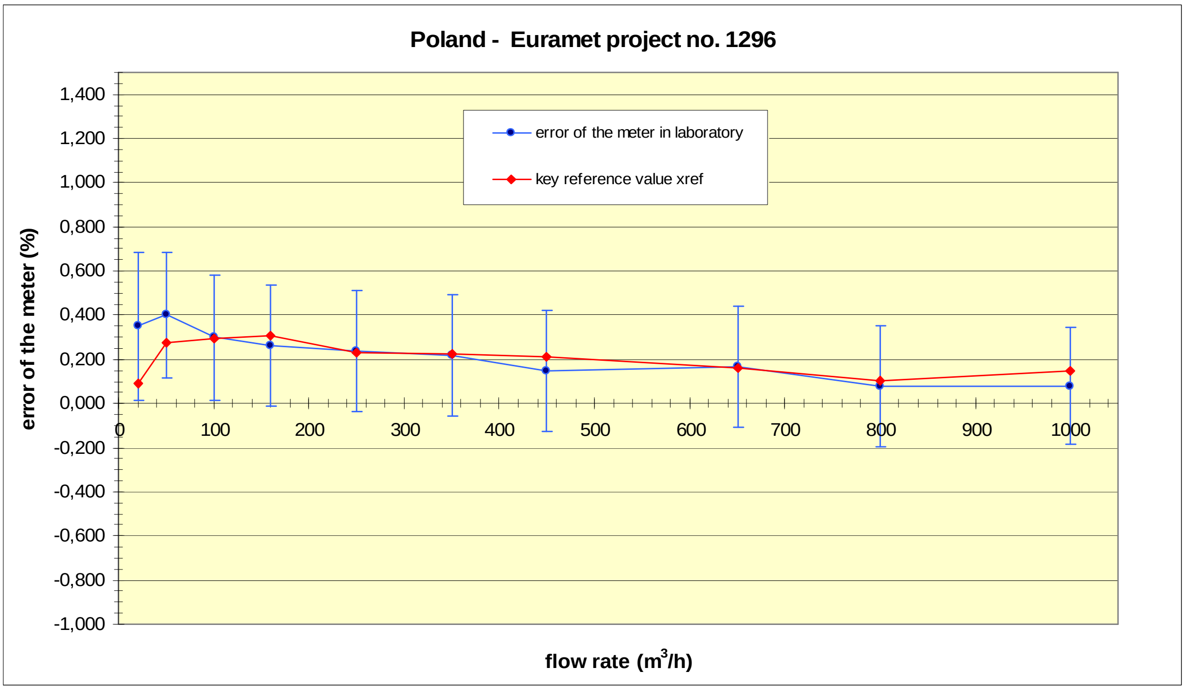
7.1.2. The Netherlands

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	consistency check	di	Ei	result
m³/h	%	%	%	%	%	%				
1000	0.140	0.150	0.150	0.158	0.148	0.065	inside	-0.01	0.06	passed
800	0.090	0.150	0.150	0.158	0.103	0.066	inside	-0.01	0.09	passed
650	0.190	0.150	0.150	0.158	0.161	0.066	inside	0.03	0.20	passed
450	0.210	0.150	0.150	0.158	0.210	0.066	inside	0.00	0.00	passed
350	0.240	0.150	0.150	0.158	0.226	0.066	inside	0.01	0.10	passed
250	0.290	0.150	0.150	0.158	0.233	0.066	inside	0.06	0.40	passed
160	0.300	0.150	0.150	0.158	0.305	0.066	inside	-0.01	0.04	passed
100	0.310	0.150	0.150	0.158	0.295	0.066	inside	0.01	0.10	passed
50	0.330	0.150	0.150	0.158	0.275	0.066	inside	0.05	0.38	passed
20	0.150	0.150	0.150	0.158	0.089	0.067	inside	0.06	0.43	passed
							mean	**0.02**	**0.18**	**passed**



7.1.3. Poland

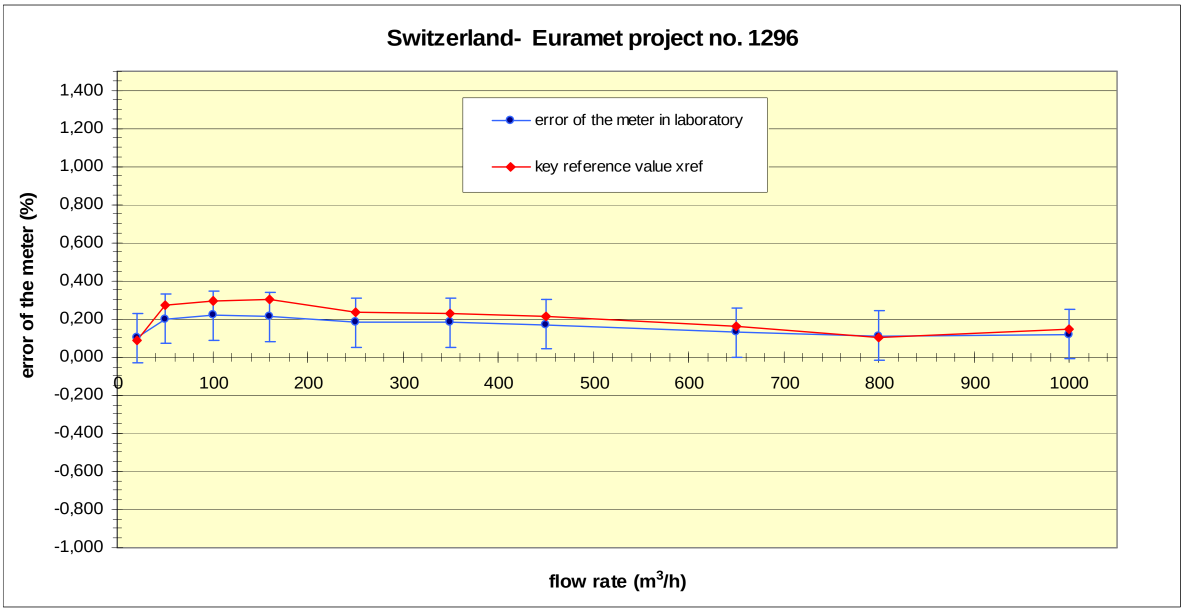
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	consistency check	di	Ei	result
m³/h	%	%	%	%	%	%				
1000	0.080	0.260	0.260	0.264	0.148	0.065	inside	-0.07	0.27	passed
800	0.080	0.270	0.260	0.274	0.103	0.066	inside	-0.02	0.09	passed
650	0.170	0.270	0.260	0.274	0.161	0.066	inside	0.01	0.03	passed
450	0.150	0.270	0.260	0.274	0.210	0.066	inside	-0.06	0.23	passed
350	0.220	0.270	0.260	0.274	0.226	0.066	inside	-0.01	0.02	passed
250	0.240	0.270	0.260	0.274	0.233	0.066	inside	0.01	0.03	passed
160	0.260	0.270	0.260	0.274	0.305	0.066	inside	-0.05	0.17	passed
100	0.300	0.280	0.260	0.284	0.295	0.066	inside	0.00	0.02	passed
50	0.400	0.280	0.260	0.284	0.275	0.066	inside	0.12	0.45	passed
20	0.350	0.330	0.260	0.333	0.089	0.067	inside	0.26	0.80	passed
							mean	**0.02**	**0.21**	**passed**



7.1.4. Switzerland

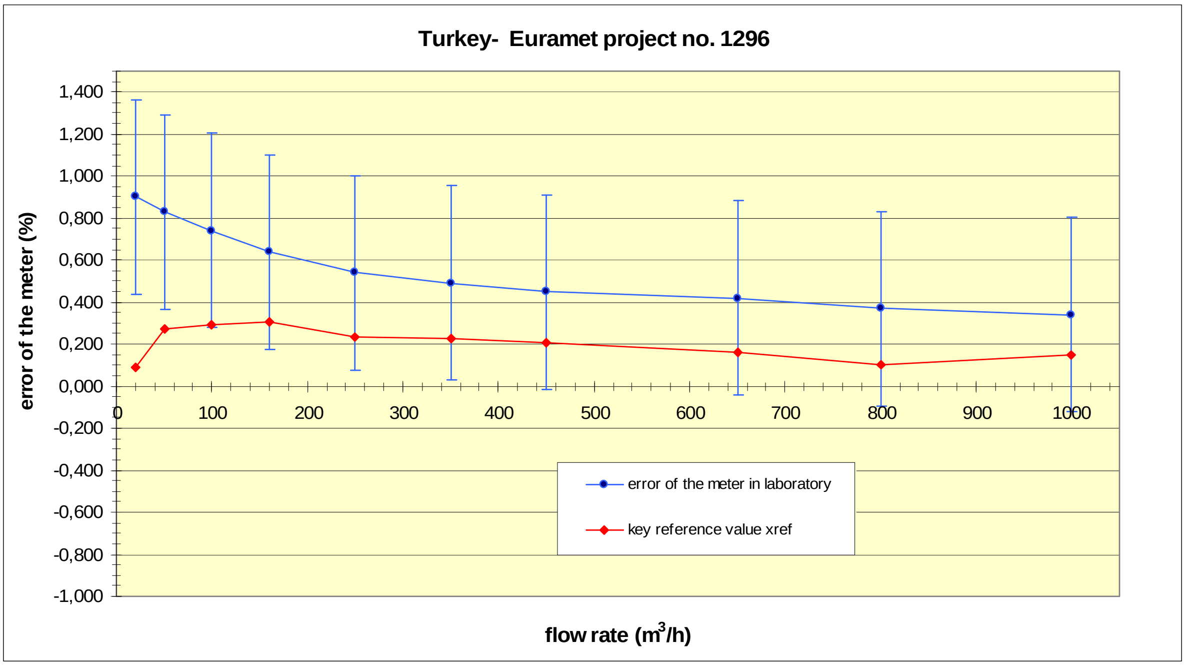
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	consistency check	di	Ei	result
m^3/h	%	%	%	%	%	%				
1000	0.120	0.120	0.150	0.129	0.148	0.065	inside	-0.03	0.26	passed
800	0.110	0.120	0.150	0.129	0.103	0.066	inside	0.01	0.06	passed
650	0.130	0.120	0.150	0.129	0.161	0.066	inside	-0.03	0.28	passed
450	0.170	0.120	0.150	0.129	0.210	0.066	inside	-0.04	0.36	passed
350	0.180	0.120	0.150	0.129	0.226	0.066	inside	-0.05	0.41	passed
250	0.180	0.120	0.150	0.129	0.233	0.066	inside	-0.05	0.47	passed
160	0.210	0.120	0.150	0.129	0.305	0.066	inside	-0.10	0.85	passed
100	0.220	0.120	0.150	0.129	0.295	0.066	inside	-0.08	0.68	passed
50	0.200	0.120	0.150	0.129	0.275	0.066	inside	-0.08	0.67	passed
20	0.100	0.120	0.150	0.129	0.089	0.067	inside	0.01	0.10	passed
							mean	**-0.04**	**0.41**	**passed**

NOTE: The determined uncertainties in the table mentioned above are less than uncertainties declared in CMC. Federal Institute of Metrology METAS is considering reducing uncertainties declared in CMC to 0.12 % during the next CMC revision.



7.1.5. Turkey

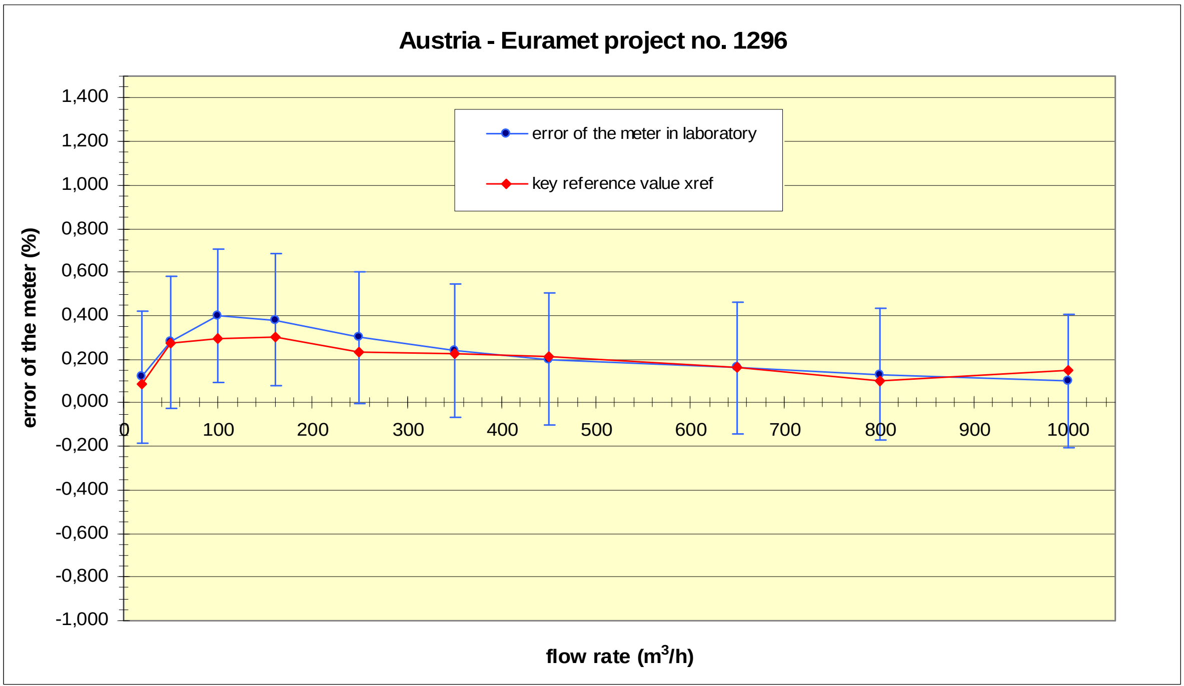
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	consistency check	di	Ei	result
m³/h	%	%	%	%	%	%				
1000	0.340	0.460	0.450	0.463	0.148	0.065	inside	0.19	0.42	passed
800	0.370	0.460	0.450	0.463	0.103	0.066	inside	0.27	0.58	passed
650	0.420	0.460	0.450	0.463	0.161	0.066	inside	0.26	0.57	passed
450	0.450	0.460	0.450	0.463	0.210	0.066	inside	0.24	0.52	passed
350	0.490	0.460	0.450	0.463	0.226	0.066	inside	0.26	0.58	passed
250	0.540	0.460	0.450	0.463	0.233	0.066	inside	0.31	0.67	passed
160	0.640	0.460	0.450	0.463	0.305	0.066	inside	0.33	0.73	passed
100	0.740	0.460	0.450	0.463	0.295	0.066	inside	0.44	0.97	passed
50	0.830	0.460	0.450	0.463	0.275	0.066	inside	0.55	1.21	failed
20	0.900	0.460	0.450	0.463	0.089	0.067	outside	0.81	1.74	failed
							mean	0.37	0.80	passed



7.2. Dependent laboratories

7.2.1. Austria

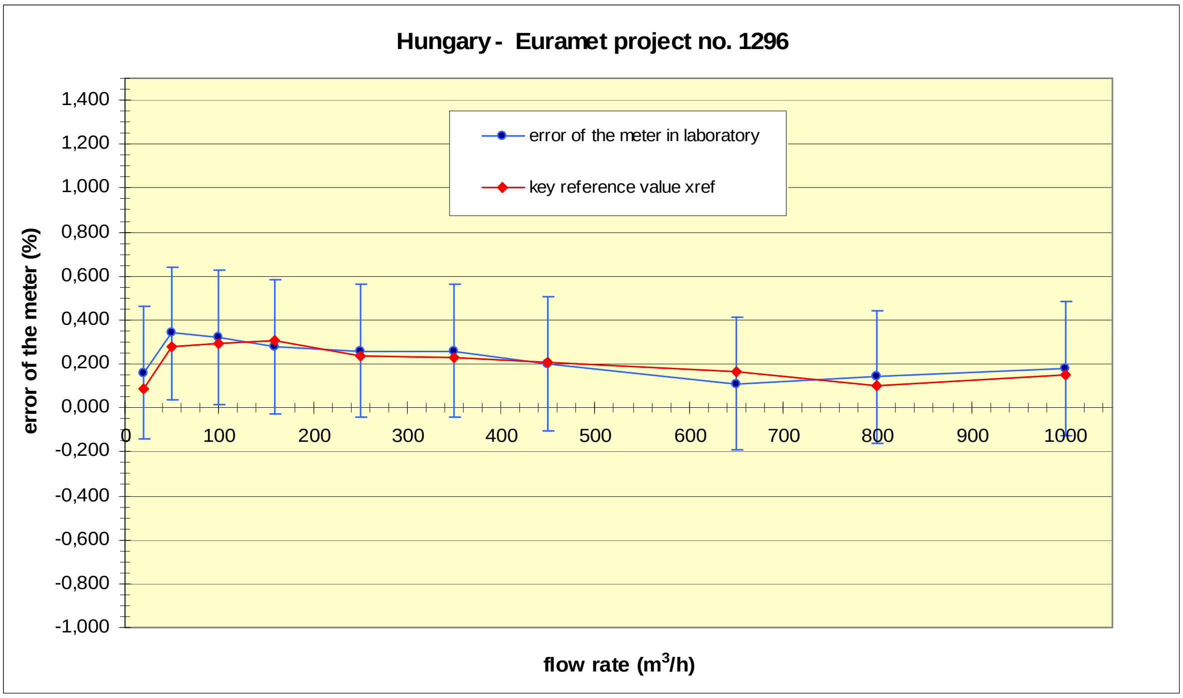
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	0.100	0.300	0.300	0.304	0.148	0.065	-0.05	0.16	passed
800	0.130	0.300	0.300	0.304	0.103	0.066	0.03	0.09	passed
650	0.160	0.300	0.300	0.304	0.161	0.066	0.00	0.00	passed
450	0.200	0.300	0.300	0.304	0.210	0.066	-0.01	0.04	passed
350	0.240	0.300	0.300	0.304	0.226	0.066	0.01	0.05	passed
250	0.300	0.300	0.300	0.304	0.233	0.066	0.07	0.23	passed
160	0.380	0.300	0.300	0.304	0.305	0.066	0.07	0.25	passed
100	0.400	0.300	0.300	0.304	0.295	0.066	0.10	0.35	passed
50	0.280	0.300	0.300	0.304	0.275	0.066	0.00	0.02	passed
20	0.120	0.300	0.300	0.304	0.089	0.067	0.03	0.11	passed
						mean	**0.03**	**0.13**	**passed**



7.2.2. Hungary

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	0.180	0.300	0.300	0.304	0.148	0.065	0.03	0.11	passed
800	0.140	0.300	0.300	0.304	0.103	0.066	0.04	0.12	passed
650	0.110	0.300	0.300	0.304	0.161	0.066	-0.05	0.17	passed
450	0.200	0.300	0.300	0.304	0.210	0.066	-0.01	0.04	passed
350	0.260	0.300	0.300	0.304	0.226	0.066	0.03	0.12	passed
250	0.260	0.300	0.300	0.304	0.233	0.066	0.03	0.09	passed
160	0.280	0.300	0.300	0.304	0.305	0.066	-0.03	0.08	passed
100	0.320	0.300	0.300	0.304	0.295	0.066	0.02	0.08	passed
50	0.340	0.300	0.300	0.304	0.275	0.066	0.06	0.22	passed
20	0.160	0.300	0.300	0.304	0.089	0.067	0.07	0.24	passed
						mean	**0.02**	**0.13**	**passed**

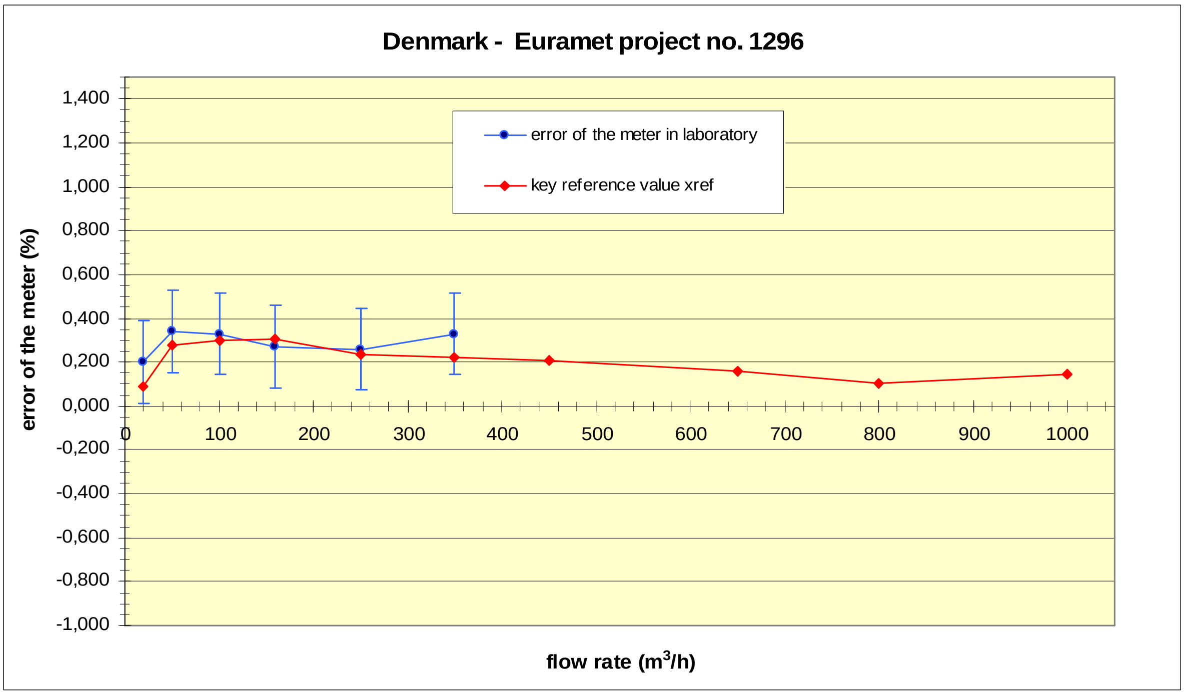
NOTE: The tests for this inter-comparison were performed in laboratory Flogiston Kft., H-2000 Szentendre, Kőzúzó u. 5, Hungary. This laboratory is a subcontractor of MKEH (Hungarian Trade Licensing Office). MKEH is accredited by Hungarian Accreditation Body for calibrations of gas meters at Flogiston Kft. The laboratory of Flogiston Kft. for calibration and verification of gas meters is under control of MKEH. (Flogiston Kft. does not make calibrations without presence of MKEH represent.)



7.2.3. Denmark

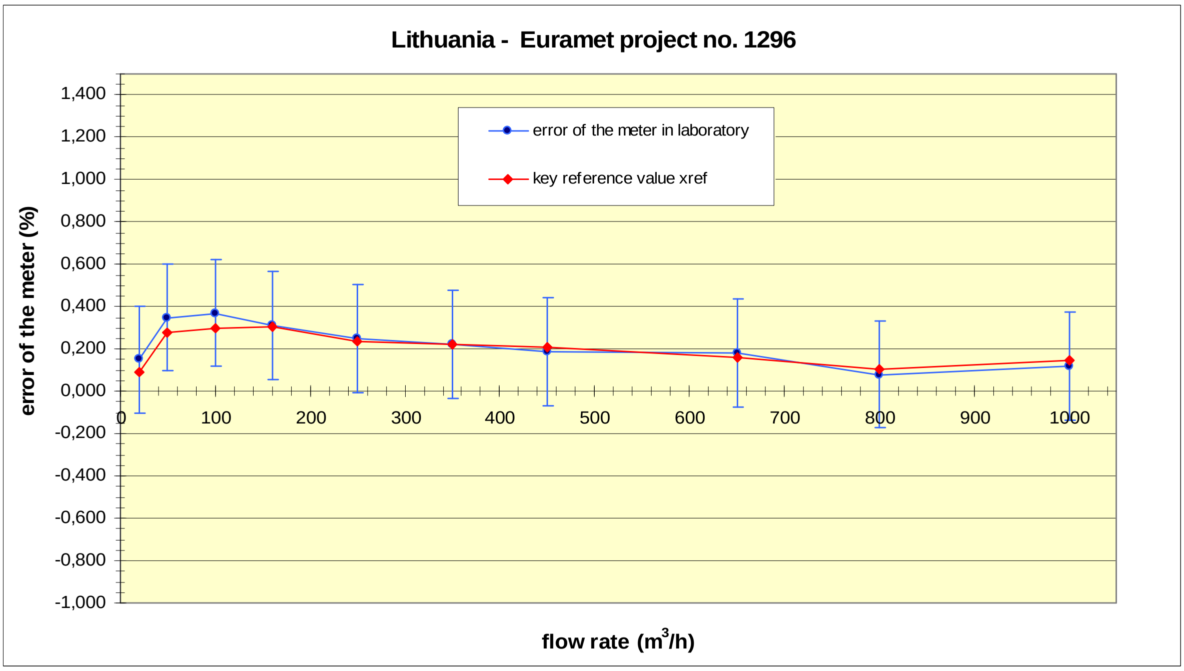
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m^3/h	%	%	%	%	%	%			
1000	-	-	-	-	-	-	-	-	-
800	-	-	-	-	-	-	-	-	-
650	-	-	-	-	-	-	-	-	-
450	-	-	-	-	-	-	-	-	-
350	0.330	0.180	0.240	0.186	0.226	0.066	0.10	0.60	passed
250	0.260	0.180	0.240	0.186	0.233	0.066	0.03	0.16	passed
160	0.270	0.180	0.240	0.186	0.305	0.066	-0.04	0.20	passed
100	0.330	0.180	0.240	0.186	0.295	0.066	0.03	0.20	passed
50	0.340	0.180	0.240	0.186	0.275	0.066	0.06	0.37	passed
20	0.200	0.180	0.240	0.186	0.089	0.067	0.11	0.64	passed
						mean	**0.05**	**0.36**	**passed**

NOTE: The determined uncertainties in the table mentioned above are less than uncertainties declared in CMC. FORCE Technology is considering reducing uncertainties declared in CMC to 0.18 % during the next CMC revision. The calibration and measurement capability under accreditation of FORCE Technology is 0.18 %.



7.2.4. Lithuania

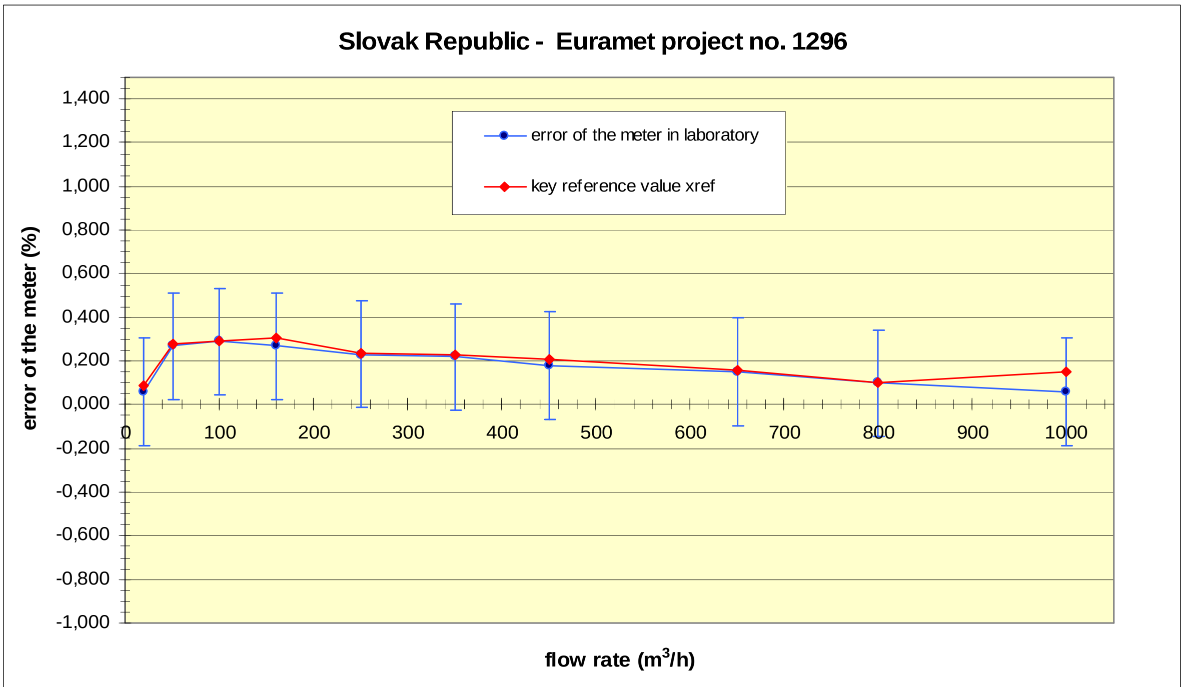
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	0.120	0.250	0.250	0.255	0.148	0.065	-0.03	0.12	passed
800	0.080	0.250	0.250	0.255	0.103	0.066	-0.02	0.09	passed
650	0.180	0.250	0.250	0.255	0.161	0.066	0.02	0.08	passed
450	0.190	0.250	0.250	0.255	0.210	0.066	-0.02	0.08	passed
350	0.220	0.250	0.250	0.255	0.226	0.066	-0.01	0.02	passed
250	0.250	0.250	0.250	0.255	0.233	0.066	0.02	0.07	passed
160	0.310	0.250	0.250	0.255	0.305	0.066	0.00	0.02	passed
100	0.370	0.250	0.250	0.255	0.295	0.066	0.07	0.30	passed
50	0.350	0.250	0.250	0.255	0.275	0.066	0.07	0.30	passed
20	0.150	0.250	0.250	0.255	0.089	0.067	0.06	0.25	passed
						mean	**0.02**	**0.13**	**passed**



7.2.5. Slovak Republic

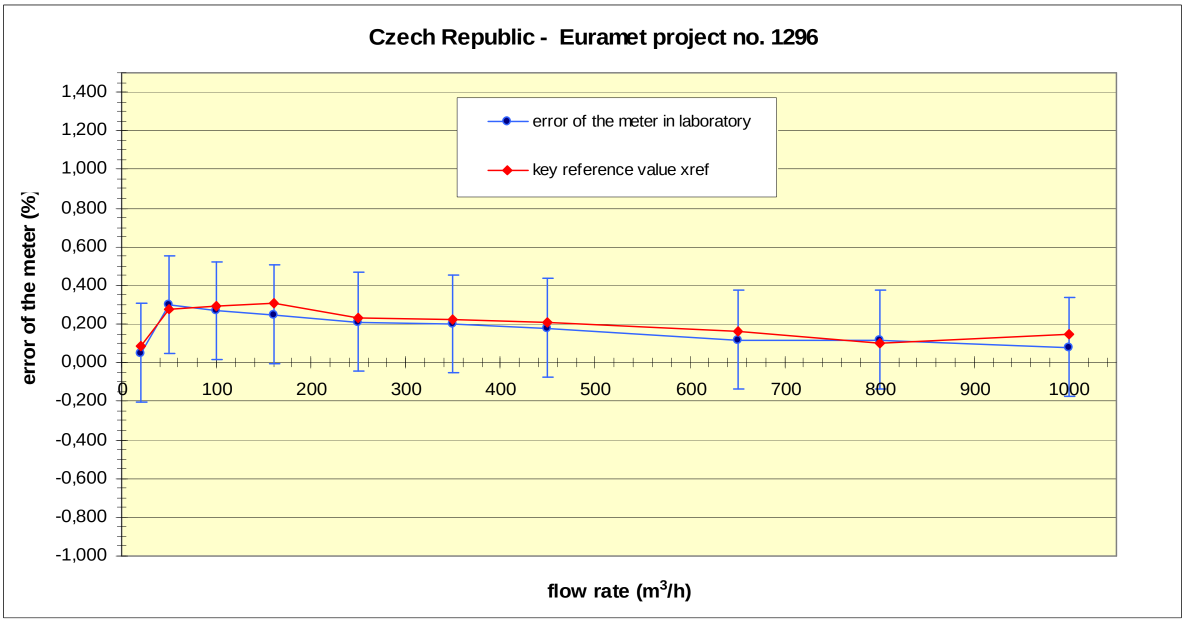
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	0.060	0.240	-	0.245	0.148	0.065	-0.09	0.38	passed
800	0.100	0.240	-	0.245	0.103	0.066	0.00	0.01	passed
650	0.150	0.240	-	0.245	0.161	0.066	-0.01	0.05	passed
450	0.180	0.240	-	0.245	0.210	0.066	-0.03	0.13	passed
350	0.220	0.240	0.200	0.245	0.226	0.066	-0.01	0.02	passed
250	0.230	0.240	0.200	0.245	0.233	0.066	0.00	0.01	passed
160	0.270	0.240	0.200	0.245	0.305	0.066	-0.04	0.15	passed
100	0.290	0.240	0.200	0.245	0.295	0.066	-0.01	0.02	passed
50	0.270	0.240	0.200	0.245	0.275	0.066	-0.01	0.02	passed
20	0.060	0.240	0.200	0.245	0.089	0.067	-0.03	0.12	passed
						mean	**-0.02**	**0.09**	**passed**

NOTE: The determined uncertainties in the table mentioned above are different than uncertainties declared in CMC. Slovak Institute of Metrology (SMU) did not used its own test facility. The test facility located in Metrological laboratory of company ELSTER Stará Turá was used in this inter-comparison. Tests in this inter-comparison were carried out under the supervision of technical experts of SMU and inspections of used equipment is ensured by SMU.



7.2.6. Czech Republic

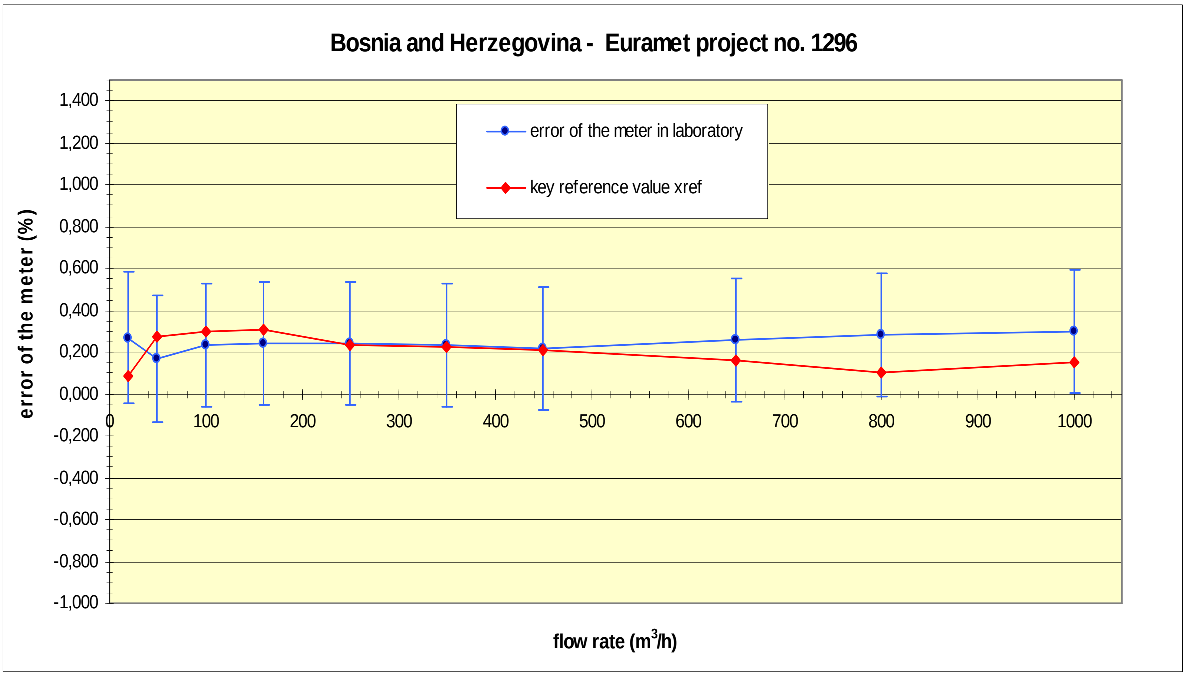
flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m^3/h	%	%	%	%	%	%			
1000	0.080	0.250	0.250	0.255	0.148	0.065	-0.07	0.28	passed
800	0.120	0.250	0.250	0.255	0.103	0.066	0.02	0.07	passed
650	0.120	0.250	0.250	0.255	0.161	0.066	-0.04	0.17	passed
450	0.180	0.250	0.250	0.255	0.210	0.066	-0.03	0.12	passed
350	0.200	0.250	0.250	0.255	0.226	0.066	-0.03	0.10	passed
250	0.210	0.250	0.250	0.255	0.233	0.066	-0.02	0.09	passed
160	0.250	0.250	0.250	0.255	0.305	0.066	-0.06	0.22	passed
100	0.270	0.250	0.250	0.255	0.295	0.066	-0.03	0.10	passed
50	0.300	0.250	0.250	0.255	0.275	0.066	0.02	0.10	passed
20	0.050	0.250	0.250	0.255	0.089	0.067	-0.04	0.16	passed
						mean	**-0.03**	**0.14**	**passed**



7.2.7. Bosnia and Herzegovina

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	0.300	0.290	no CMC	0.294	0.148	0.065	0.15	0.53	passed
800	0.280	0.290	no CMC	0.294	0.103	0.066	0.18	0.62	passed
650	0.260	0.290	no CMC	0.294	0.161	0.066	0.10	0.34	passed
450	0.220	0.290	no CMC	0.294	0.210	0.066	0.01	0.03	passed
350	0.230	0.290	no CMC	0.294	0.226	0.066	0.00	0.02	passed
250	0.240	0.290	no CMC	0.294	0.233	0.066	0.01	0.02	passed
160	0.240	0.290	no CMC	0.294	0.305	0.066	-0.07	0.23	passed
100	0.230	0.290	no CMC	0.294	0.295	0.066	-0.07	0.23	passed
50	0.170	0.300	no CMC	0.304	0.275	0.066	-0.11	0.35	passed
20	0.270	0.310	no CMC	0.314	0.089	0.067	0.18	0.59	passed
						mean	**0.04**	**0.30**	**passed**

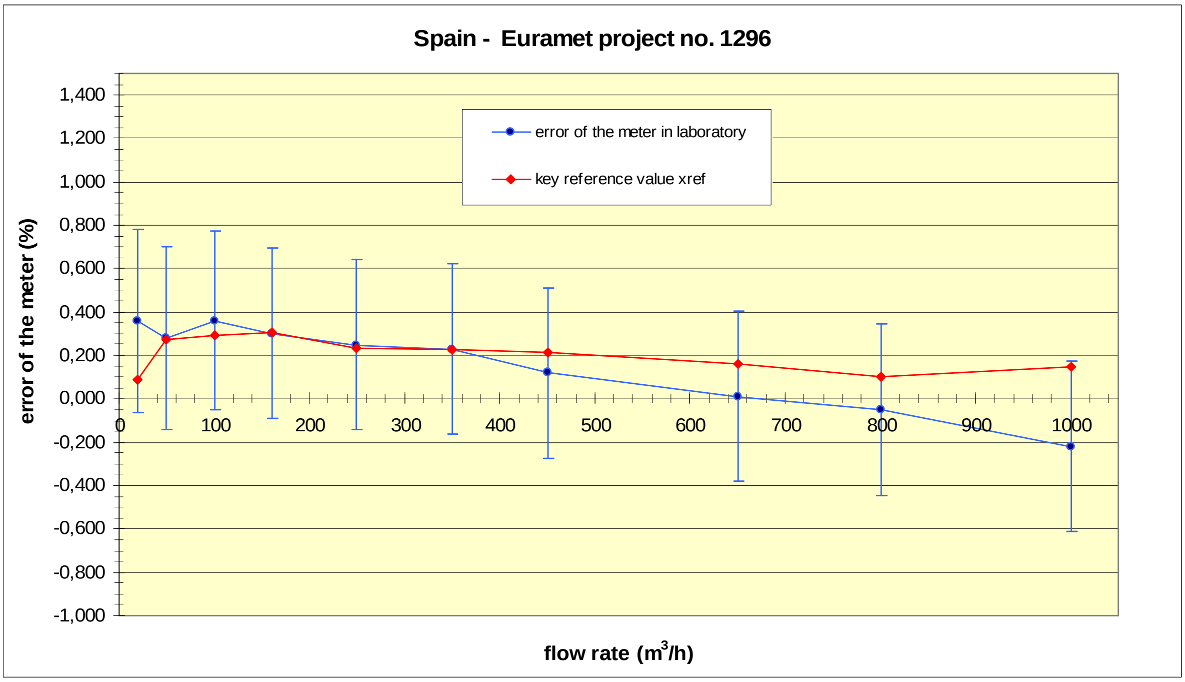
NOTE: The determined uncertainties in the table mentioned above are different than uncertainties declared in CMC. Institute of Metrology of Bosnia and Herzegovina (IMBIH) used in this inter-comparison the test facility located in SARAJEVOGAS, LABORATORIJ ZA ISPITIVANJE I KALIBRACIJU MJERNIH INSTRUMENATA ZA GAS Rajlovacka st., 71000 Sarajevo. This laboratory is a subcontractor of IMBIH.



7.2.8. Spain

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	uncertainty declared in CMC U(k=2)	uncertainty of the error including stability of the meter U(k=2)	key reference value x_{ref}	expanded uncertainty of the key refrence value $U(x_{ref})$	di	Ei	result
m³/h	%	%	%	%	%	%			
1000	-0.220	0.390	no CMC	0.393	0.148	0.065	-0.37	0.95	passed
800	-0.050	0.390	no CMC	0.393	0.103	0.066	-0.15	0.40	passed
650	0.010	0.390	no CMC	0.393	0.161	0.066	-0.15	0.39	passed
450	0.120	0.390	no CMC	0.393	0.210	0.066	-0.09	0.23	passed
350	0.230	0.390	no CMC	0.393	0.226	0.066	0.00	0.01	passed
250	0.250	0.390	no CMC	0.393	0.233	0.066	0.02	0.04	passed
160	0.300	0.390	no CMC	0.393	0.305	0.066	-0.01	0.01	passed
100	0.360	0.410	no CMC	0.413	0.295	0.066	0.06	0.16	passed
50	0.280	0.420	no CMC	0.423	0.275	0.066	0.00	0.01	passed
20	0.360	0.420	no CMC	0.423	0.089	0.067	0.27	0.65	passed
						mean	**-0.04**	**0.29**	**passed**

NOTE: The determined uncertainties in the table mentioned above are different than uncertainties declared in CMC. Centro Español de Metrología (CEM) used in this inter-comparison the test facility located in Enagás, S.A., LABORATORIO DE CONTADORES DE GAS, Autovía A-2, km. 306,4. 50012 – ZARAGOZA (SPAIN). This laboratory is a subcontractor of CEM.



6. Degree of equivalence between laboratories

As it was mentioned above in this project there were 5 independent laboratories (---):
Germany, The Netherlands, Poland, Switzerland, Turkey

In this project there were 5 laboratories traceable to Netherlands (VSL):
Austria, Hungary, Denmark, Slovak Republic, Bosnia and Herzegovina

In this project there were 3 laboratories traceable to Germany (PTB):
Spain, Czech Republic, Lithuania

The degree of equivalence between laboratory *i* and laboratory *j* was calculated as the pair of values *dij* and *Eij* (equations [12], [14], [19], [20], [22], see chapter 6.1.2.). The calculated pairs of values *dij* and *Eij* are mentioned down in tables.

The pair of values is red if *Eij* is higher than 1.2. It means that the mutual degree of equivalence of laboratories *i* and *j* failed.

The pair of values is light orange if *Eij* is higher than 1 and equal or less than 1.2. It means that the mutual degree of equivalence of laboratories *i* and *j* is in warning level.

The pair of values is black if *Eij* is equal or less than 1. It means that there is satisfactory mutual degree of equivalence of laboratories *i* and *j*.

In the parentheses there is a source of traceability mentioned.

Q	Austria (VSL)	Hungary VSL)	Austria (VSL)	Germany (PTB)	Austria (VSL)	Netherl. (VSL	Austria (VSL)	Denmark (VSL)	Austria (VSL)	Poland	Austria (VSL)	Lith. (PTB)	Austria (VSL)	Slovak Rep. (VSL)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-0.08	0.21	-0.07	0.21	-0.04	0.15	-	-	0.02	0.05	-0.02	0.05	0.04	0.12
800	-0.01	0.03	0.03	0.11	0.04	0.15	-	-	0.05	0.12	0.05	0.13	0.03	0.09
650	0.05	0.13	0.00	0.01	-0.03	0.11	-	-	-0.01	0.02	-0.02	0.05	0.01	0.03
450	0.00	0.00	-0.03	0.09	-0.01	0.04	-	-	0.05	0.12	0.01	0.03	0.02	0.06
350	-0.02	0.05	0.01	0.02	0.00	0.00	-0.09	0.29	0.02	0.05	0.02	0.05	0.02	0.06
250	0.04	0.11	0.07	0.23	0.01	0.04	0.04	0.29	0.06	0.15	0.05	0.13	0.07	0.21
160	0.10	0.27	0.03	0.10	0.08	0.30	0.11	0.29	0.12	0.29	0.07	0.18	0.11	0.34
100	0.08	0.21	0.09	0.28	0.09	0.34	0.07	0.29	0.10	0.24	0.03	0.08	0.11	0.34
50	-0.06	0.16	0.02	0.07	-0.05	0.19	-0.06	0.29	-0.12	0.29	-0.07	0.18	0.01	0.03
20	-0.04	0.11	0.08	0.25	-0.03	0.11	-0.08	0.29	-0.23	0.51	-0.03	0.08	0.06	0.18
Mean	**0.01**	**0.13**	**0.02**	**0.14**	**0.01**	**0.14**	**0.00**	**0.29**	**0.01**	**0.18**	**0.01**	**0.09**	**0.05**	**0.15**

Q	Austria-(VSL)	Czech Rep (PTB)	Austria (VSL)	Switz.	Austria (VSL)	Bos. and Herz. (VSL)	Austria (VSL)	Turkey	Austria (VSL)	Spain (PTB)	Hungary (VSL)	Germany (PTB)	Hungary (VSL)	Neth. (VSL)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	0.02	0.05	-0.02	0.06	-0.20	0.55	-0.24	0.43	0.32	0.64	0.01	0.04	0.04	0.15
800	0.01	0.03	0.02	0.06	-0.15	0.41	-0.24	0.43	0.18	0.36	0.04	0.14	0.05	0.19
650	0.04	0.10	0.03	0.09	-0.10	0.27	-0.26	0.47	0.15	0.30	-0.05	0.14	-0.08	0.30
450	0.02	0.05	0.03	0.09	-0.02	0.05	-0.25	0.45	0.08	0.16	-0.03	0.09	-0.01	0.04
350	0.04	0.10	0.06	0.18	0.01	0.03	-0.25	0.45	0.01	0.02	0.03	0.08	0.02	0.07
250	0.09	0.23	0.12	0.36	0.06	0.16	-0.24	0.43	0.05	0.10	0.03	0.10	-0.03	0.11
160	0.13	0.33	0.17	0.51	0.14	0.38	-0.26	0.47	0.08	0.16	-0.07	0.21	-0.02	0.07
100	0.13	0.33	0.18	0.55	0.17	0.46	-0.34	0.61	0.04	0.08	0.01	0.03	0.01	0.04
50	-0.02	0.05	0.08	0.24	0.11	0.29	-0.55	0.99	0.00	0.00	0.08	0.25	0.01	0.04
20	0.07	0.18	0.02	0.06	-0.15	0.39	**-0.78**	**1.41**	-0.24	0.46	0.12	0.37	0.01	0.04
Mean	**0.05**	**0.14**	**0.07**	**0.22**	**-0.01**	**0.30**	**-0.34**	**0.62**	**0.07**	**0.23**	**0.02**	**0.15**	**0.00**	**0.10**

Q	Hungary (VSL)	Denmark (VSL)	Hungary (VSL)	Poland	Hungary (VSL)	Lith (PTB)	Hungary (VSL)	Slovak Rep. (VSL)	Hungary (VSL)	Czech Rep. (PTB)	Hungary (VSL)	Switz.	Hungary (VSL)	Bosn. And Herz. (VSL)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-	-	0.10	0.25	0.06	0.15	0.12	0.37	0.10	0.25	0.06	0.18	-0.12	0.33
800	-	-	0.06	0.15	0.06	0.15	0.04	0.12	0.02	0.05	0.03	0.09	-0.14	0.38
650	-	-	-0.06	0.15	-0.07	0.18	-0.04	0.12	-0.01	0.03	-0.02	0.06	-0.15	0.41
450	-	-	0.05	0.12	0.01	0.03	0.02	0.06	0.02	0.05	0.03	0.09	-0.02	0.05
350	-0.07	0.24	0.04	0.10	0.04	0.10	0.04	0.12	0.06	0.15	0.08	0.24	0.03	0.08
250	0.00	0.00	0.02	0.05	0.01	0.03	0.03	0.09	0.05	0.13	0.08	0.24	0.02	0.05
160	0.01	0.03	0.02	0.05	-0.03	0.08	0.01	0.03	0.03	0.08	0.07	0.21	0.04	0.11
100	-0.01	0.03	0.02	0.05	-0.05	0.13	0.03	0.09	0.05	0.13	0.10	0.30	0.09	0.25
50	0.00	0.00	-0.06	0.14	-0.01	0.03	0.07	0.21	0.04	0.10	0.14	0.42	0.17	0.45
20	-0.04	0.14	-0.19	0.42	0.01	0.03	0.10	0.31	0.11	0.28	0.06	0.18	-0.11	0.29
Mean	**-0.02**	**0.08**	**0.00**	**0.15**	**0.00**	**0.09**	**0.04**	**0.15**	**0.05**	**0.12**	**0.06**	**0.20**	**-0.02**	**0.24**

Q	Hungary (VSL)	Turkey	Hungary (VSL)	Spain (PTB)	Germany (PTB)	Netherl. (VSL)	Germany (PTB)	Denmark (VSL)	Germany (PTB)	Poland	Germany (PTB)	Lith. (PTB)	Germany (PTB)	Slovak Rep. (VSL)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-0.16	0.29	0.40	0.81	0.03	0.15	-	-	0.09	0.31	0.05	0.19	0.11	0.41
800	-0.23	0.42	0.19	0.38	0.01	0.03	-	-	0.02	0.06	0.02	0.06	0.00	0.02
650	-0.31	0.56	0.10	0.20	-0.03	0.19	-	-	-0.01	0.05	-0.02	0.10	0.01	0.02
450	-0.25	0.45	0.08	0.16	0.02	0.10	-	-	0.08	0.27	0.04	0.16	0.05	0.19
350	-0.23	0.42	0.03	0.06	-0.01	0.03	-0.10	0.46	0.01	0.05	0.01	0.06	0.01	0.05
250	-0.28	0.51	0.01	0.02	-0.06	0.34	-0.03	0.16	-0.01	0.04	-0.02	0.09	0.00	0.01
160	-0.36	0.65	-0.02	0.04	0.05	0.26	0.08	0.37	0.09	0.30	0.04	0.15	0.08	0.30
100	-0.42	0.76	-0.04	0.08	0.00	0.01	-0.02	0.09	0.01	0.04	-0.06	0.24	0.02	0.08
50	-0.49	0.89	0.06	0.12	-0.07	0.39	-0.08	0.39	-0.14	0.47	-0.09	0.37	-0.01	0.04
20	**-0.74**	**1.34**	-0.20	0.38	-0.11	0.60	-0.16	0.76	-0.31	0.89	-0.11	0.44	-0.02	0.07
Mean	**-0.35**	**0.63**	**0.06**	**0.22**	**-0.02**	**0.21**	**-0.05**	**0.37**	**-0.02**	**0.25**	**-0.02**	**0.19**	**0.02**	**0.12**

Q	Germany (PTB)	Czech Rep. (PTB)	Germany (PTB)	Switzer.	Germany (PTB)	Bosn. and Herz. (VSL)	Germany (PTB)	Turkey	Germany (PTB)	Spain (PTB)	Netherl (VSL)	Denmark (VSL)	Netherl (VSL)	Poland
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	0.09	0.35	0.05	0.29	-0.13	0.43	-0.17	0.37	0.39	1.00	-	-	0.06	0.19
800	-0.02	0.10	-0.01	0.09	-0.18	0.60	-0.27	0.58	0.15	0.38	-	-	0.01	0.03
650	0.04	0.15	0.03	0.16	-0.10	0.34	-0.26	0.56	0.15	0.38	-	-	0.02	0.06
450	0.05	0.20	0.06	0.37	0.01	0.03	-0.22	0.47	0.11	0.28	-	-	0.06	0.19
350	0.03	0.14	0.05	0.34	0.00	0.01	-0.26	0.54	0.00	0.01	-0.09	0.75	0.02	0.06
250	0.02	0.07	0.05	0.29	-0.01	0.04	-0.31	0.66	-0.02	0.06	0.03	0.25	0.05	0.16
160	0.10	0.40	0.14	0.87	0.11	0.35	-0.29	0.62	0.05	0.12	0.03	0.25	0.04	0.13
100	0.04	0.17	0.09	0.57	0.08	0.26	-0.43	0.91	-0.05	0.12	-0.02	0.17	0.01	0.03
50	-0.04	0.17	0.06	0.37	0.09	0.28	**-0.57**	**1.21**	-0.02	0.05	-0.01	0.08	0.07	0.22
20	-0.01	0.04	-0.06	0.37	-0.23	0.70	**-0.86**	**1.82**	-0.32	0.76	-0.05	0.41	0.20	0.54
Mean	**0.03**	**0.18**	**0.04**	**0.37**	**-0.04**	**0.30**	**-0.37**	**0.77**	**0.04**	**0.32**	**-0.02**	**0.32**	**0.05**	**0.16**

Q	Netherl (VSL)	Lith. (PTB)	Netherl (VSL)	Slovak Rep. (VSL)	Netherl (VSL)	Czech Rep. (PTB)	Netherl (VSL)	Switz.	Netherl (VSL)	Bosn.and Herz. (VSL)	Netherl (VSL)	Turkey	Netherl (VSL)	Spain (PTB)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	0.02	0.07	0.08	0.40	0.06	0.20	0.02	0.10	-0.16	0.62	-0.20	0.41	0.36	0.98
800	0.01	0.03	-0.01	0.05	-0.03	0.10	-0.02	0.10	-0.19	0.74	-0.28	0.57	0.14	0.38
650	0.01	0.03	0.04	0.20	0.07	0.23	0.06	0.29	-0.07	0.27	-0.23	0.47	0.18	0.49
450	0.02	0.07	0.03	0.15	0.03	0.10	0.04	0.20	-0.01	0.04	-0.24	0.49	0.09	0.25
350	0.02	0.07	0.02	0.10	0.04	0.13	0.06	0.29	0.01	0.04	-0.25	0.51	0.01	0.03
250	0.04	0.13	0.06	0.30	0.08	0.27	0.11	0.54	0.05	0.19	-0.25	0.51	0.04	0.11
160	-0.01	0.03	0.03	0.15	0.05	0.17	0.09	0.44	0.06	0.23	-0.34	0.70	0.00	0.00
100	-0.06	0.20	0.02	0.10	0.04	0.13	0.09	0.44	0.08	0.31	-0.43	0.88	-0.05	0.13
50	-0.02	0.07	0.06	0.30	0.03	0.10	0.13	0.64	0.16	0.60	-0.50	1.02	0.05	0.13
20	0.00	0.00	0.09	0.45	0.10	0.33	0.05	0.25	-0.12	0.43	**-0.75**	**1.53**	-0.21	0.53
Mean	**0.00**	**0.07**	**0.04**	**0.22**	**0.05**	**0.18**	**0.06**	**0.33**	**-0.02**	**0.35**	**-0.35**	**0.71**	**0.06**	**0.30**

Q	Denmark (VSL)	Poland	Denmark (VSL)	Lith. (PTB)	Denmark (VSL)	Slovak Rep. (VSL)	Denmark (VSL)	Czech Rep. (PTB)	Denmark (VSL)	Switz.	Denmark (VSL)	Bosn.and Herz. (VSL)	Denmark (VSL)	Turkey
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
650	-	-	-	-	-	-	-	-	-	-	-	-	-	-
450	-	-	-	-	-	-	-	-	-	-	-	-	-	-
350	0.11	0.33	0.11	0.35	0.11	0.49	0.13	0.41	0.15	0.66	0.10	0.36	-0.16	0.32
250	0.02	0.06	0.01	0.03	0.03	0.13	0.05	0.16	0.08	0.35	0.02	0.07	-0.28	0.56
160	0.01	0.03	-0.04	0.13	0.00	0.00	0.02	0.06	0.06	0.26	0.03	0.11	-0.37	0.74
100	0.03	0.09	-0.04	0.13	0.04	0.18	0.06	0.19	0.11	0.49	0.10	0.36	-0.41	0.82
50	-0.06	0.18	-0.01	0.03	0.07	0.31	0.04	0.13	0.14	0.62	0.17	0.59	-0.49	0.98
20	-0.15	0.39	0.05	0.16	0.14	0.63	0.15	0.48	0.10	0.44	-0.07	0.24	**-0.70**	**1.40**
Mean	**-0.01**	**0.18**	**0.01**	**0.14**	**0.07**	**0.29**	**0.08**	**0.24**	**0.11**	**0.47**	**0.06**	**0.29**	**-0.40**	**0.81**

Q	Denmark (VSL)	Spain (PTB	Poland	Lith. (PTB)	Poland	Slovak Rep. (VSL)	Poland	Czech Rep. (PTB)	Poland	Switz.	Poland	Bosn. and Herz. (VSL)	Poland	Turkey
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-	-	-0.04	0.11	0.02	0.06	0.00	0.00	-0.04	0.14	-0.22	0.56	-0.26	0.49
800	-	-	0.00	0.00	-0.02	0.05	-0.04	0.11	-0.03	0.10	-0.20	0.50	-0.29	0.54
650	-	-	-0.01	0.03	0.02	0.05	0.05	0.13	0.04	0.13	-0.09	0.22	-0.25	0.46
450	-	-	-0.04	0.11	-0.03	0.08	-0.03	0.08	-0.02	0.07	-0.07	0.17	-0.30	0.56
350	0.10	0.23	0.00	0.00	0.00	0.00	0.02	0.05	0.04	0.13	-0.01	0.02	-0.27	0.50
250	0.01	0.02	-0.01	0.03	0.01	0.03	0.03	0.08	0.06	0.20	0.00	0.00	-0.30	0.56
160	-0.03	0.07	-0.05	0.13	-0.01	0.03	0.01	0.03	0.05	0.16	0.02	0.05	-0.38	0.71
100	-0.03	0.07	-0.07	0.18	0.01	0.03	0.03	0.08	0.08	0.26	0.07	0.17	-0.44	0.81
50	0.06	0.13	0.05	0.13	0.13	0.35	0.10	0.26	0.20	0.64	0.23	0.55	-0.43	0.79
20	-0.16	0.35	0.20	0.48	0.29	0.70	0.30	0.72	0.25	0.70	0.08	0.17	-0.55	0.96
Mean	**-0.01**	**0.14**	**0.00**	**0.12**	**0.04**	**0.14**	**0.05**	**0.15**	**0.06**	**0.25**	**-0.02**	**0.24**	**-0.35**	**0.64**

Q	Poland	Spain (PTB)	Lith. (PTB)	Slovak Rep. (VSL)	Lith. (PTB)	Czech Rep. (PTB)	Lith. (PTB)	Switz.	Lith. (PTB)	Bosn. and Herz. (VSL)	Lith. (PTB)	Turkey	Lith. (PTB)	Spain (PTB)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	0.30	0.63	0.06	0.17	0.04	0.12	0.00	0.00	-0.18	0.46	-0.22	0.42	0.34	0.75
800	0.13	0.27	-0.02	0.06	-0.04	0.12	-0.03	0.11	-0.20	0.51	-0.29	0.55	0.13	0.29
650	0.16	0.33	0.03	0.09	0.06	0.18	0.05	0.18	-0.08	0.21	-0.24	0.45	0.17	0.37
450	0.03	0.06	0.01	0.03	0.01	0.03	0.02	0.07	-0.03	0.08	-0.26	0.49	0.07	0.15
350	-0.01	0.02	0.00	0.00	0.02	0.06	0.04	0.14	-0.01	0.03	-0.27	0.51	-0.01	0.02
250	-0.01	0.02	0.02	0.06	0.04	0.12	0.07	0.25	0.01	0.03	-0.29	0.55	0.00	0.00
160	-0.04	0.08	0.04	0.12	0.06	0.18	0.10	0.35	0.07	0.18	-0.33	0.63	0.01	0.02
100	-0.06	0.12	0.08	0.24	0.10	0.29	0.15	0.53	0.14	0.36	-0.37	0.70	0.01	0.02
50	0.12	0.24	0.08	0.24	0.05	0.15	0.15	0.53	0.18	0.45	-0.48	0.91	0.07	0.15
20	-0.01	0.02	0.09	0.27	0.10	0.29	0.05	0.18	-0.12	0.30	-0.75	1.42	-0.21	0.44
Mean	**0.06**	**0.18**	**0.04**	**0.13**	**0.04**	**0.15**	**0.06**	**0.23**	**-0.02**	**0.26**	**-0.35**	**0.66**	**0.06**	**0.22**

Q	Slovak Rep. (VSL)	Czech Rep. (PTB	Slovak Rep. (VSL)	Switz.	Slovak Rep. (VSL)	Bosn. and Herz. (VSL)	Slovak Rep. (VSL)	Turkey	Slovak Rep. (VSL)	Spain (PTB)	Czech Rep. (PTB)	Switz.	Czech Rep. (PTB)	Bosn. and Herz. (VSL)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-0.02	0.06	-0.06	0.22	-0.24	0.75	-0.28	0.54	0.28	0.60	-0.04	0.14	-0.22	0.57
800	-0.02	0.06	-0.01	0.04	-0.18	0.57	-0.27	0.52	0.15	0.32	0.01	0.04	-0.16	0.41
650	0.03	0.08	0.02	0.07	-0.11	0.35	-0.27	0.52	0.14	0.30	-0.01	0.04	-0.14	0.36
450	0.00	0.00	0.01	0.04	-0.04	0.13	-0.27	0.52	0.06	0.13	0.01	0.04	-0.04	0.10
350	0.02	0.06	0.04	0.14	-0.01	0.03	-0.27	0.52	-0.01	0.02	0.02	0.07	-0.03	0.08
250	0.02	0.06	0.05	0.18	-0.01	0.03	-0.31	0.59	-0.02	0.04	0.03	0.11	-0.03	0.08
160	0.02	0.06	0.06	0.22	0.03	0.09	-0.37	0.71	-0.03	0.06	0.04	0.14	0.01	0.03
100	0.02	0.06	0.07	0.25	0.06	0.19	-0.45	0.86	-0.07	0.15	0.05	0.18	0.04	0.10
50	-0.03	0.08	0.07	0.25	0.10	0.31	-0.56	1.07	-0.01	0.02	0.10	0.35	0.13	0.33
20	0.01	0.03	-0.04	0.14	-0.21	0.62	-0.84	1.61	-0.30	0.61	-0.05	0.18	-0.22	0.54
Mean	**0.01**	**0.05**	**0.02**	**0.16**	**-0.06**	**0.31**	**-0.39**	**0.74**	**0.02**	**0.23**	**0.02**	**0.13**	**-0.07**	**0.26**

Q	Czech Rep. (PTB)	Turkey	Czech Rep. (PTB)	Spain (PTB)	Switz.	Bosn. and Herz. (VSL)	Switz.	Turkey	Switz.	Spain (PTB)	Bosn. and Herz. (VSL)	Turkey	Bosn. and Herz. (VSL)	Spain (PTB)
	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei	di	Ei
1000	-0.26	0.49	0.30	0.66	-0.18	0.56	-0.22	0.46	0.34	0.82	-0.04	0.07	0.52	1.06
800	-0.25	0.47	0.17	0.37	-0.17	0.53	-0.26	0.54	0.16	0.39	-0.09	0.16	0.33	0.67
650	-0.30	0.57	0.11	0.24	-0.13	0.40	-0.29	0.60	0.12	0.29	-0.16	0.29	0.25	0.51
450	-0.27	0.51	0.06	0.13	-0.05	0.16	-0.28	0.58	0.05	0.12	-0.23	0.42	0.10	0.20
350	-0.29	0.55	-0.03	0.07	-0.05	0.16	-0.31	0.65	-0.05	0.12	-0.26	0.47	0.00	0.00
250	-0.33	0.63	-0.04	0.09	-0.06	0.19	-0.36	0.75	-0.07	0.17	-0.30	0.55	-0.01	0.02
160	-0.39	0.74	-0.05	0.11	-0.03	0.09	-0.43	0.90	-0.09	0.22	-0.40	0.73	-0.06	0.12
100	-0.47	0.89	-0.09	0.19	-0.01	0.03	-0.52	1.08	-0.14	0.32	-0.51	0.93	-0.13	0.26
50	-0.53	1.00	0.02	0.04	0.03	0.09	-0.63	1.31	-0.08	0.18	-0.66	1.19	-0.11	0.21
20	-0.85	1.61	-0.31	0.65	-0.17	0.50	-0.80	1.67	-0.26	0.59	-0.63	1.13	-0.09	0.17
Mean	**-0.39**	**0.75**	**0.01**	**0.26**	**-0.09**	**0.26**	**-0.33**	**0.69**	**0.04**	**0.31**	**-0.25**	**0.45**	**0.13**	**0.36**

Q	Turkey	Spain (PTB)
	di	Ei
1000	0.56	0.92
800	0.42	0.69
650	0.41	0.68
450	0.33	0.54
350	0.26	0.43
250	0.29	0.48
160	0.34	0.56
100	0.38	0.61
50	0.55	0.88
20	0.54	0.86
Mean	**0.37**	**0.61**

7. Summary and conclusion

The summary of results is mentioned down in the *tables 4, 5 and 6*. The independent laboratories are light pink. The laboratories with traceability to Germany (PTB) are light yellow. The laboratories with traceability to The Netherlands (VSL) are light blue.

The colour of letters and of numbers is red if there is the evaluation "failed" in tables. The colour of letters and of numbers is light orange if there is the evaluation "warning level" in tables. The colour of letters and of numbers is black if there is evaluation "passed" in tables.

The complete evaluation of each laboratory concerning the key comparison reference value in different flow rates is summarised in the *table 4*.

Table 4 – Evaluation summary of each laboratory from the point of view of key comparison reference values in different flow rates

Flow rate	Independent laboratories					Dependent laboratories							
Q	**Germany**	**Netherlands**	**Poland**	**Switzerland**	**Turkey**	**Austria**	**Hungary**	**Denmark**	**Lithuania**	**Slovak Rep.**	**Czech Rep.**	**Bosnia and Herzegovina**	**Spain**
1000	passed	passed	passed	passed	passed	passed	passed	-	passed	passed	passed	passed	passed
800	passed	passed	passed	passed	passed	passed	passed	-	passed	passed	passed	passed	passed
650	passed	passed	passed	passed	passed	passed	passed	-	passed	passed	passed	passed	passed
450	passed	passed	passed	passed	passed	passed	passed	-	passed	passed	passed	passed	passed
350	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
250	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
160	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
100	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed
50	passed	passed	passed	passed	**failed**	passed	passed	passed	passed	passed	passed	passed	passed
20	passed	passed	passed	passed	**failed**	passed	passed	passed	passed	passed	passed	passed	passed
Mean	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**	**passed**

The complete evaluation of each laboratory concerning the mean coefficients *Ei* (equation [13]) and *Eij* (equation [14]) is summarised in the *table 5*. In the **diagonal** there are the mean coefficients *Ei* which express the equivalence with the key comparison reference value. In other cells there are coefficients *Eij* which express the equivalence of one laboratory with another laboratory.

Table 5 -The complete evaluation of each laboratory concerning the mean coefficients Ei and Eij

	Slovak Rep.	Hungary	Austria	Lithuania	Czech Rep.	Netherlands	Poland	Germany	Spain	Bosnia and Herzegovina	Denmark	Switzerland	Turkey
Slovak Rep.	**0.092**	-0.153	-0.147	-0.128	0.054	-0.221	-0.137	-0.119	0.227	0.307	-0.292	0.155	0.743
Hungary	0.153	**0.127**	-0.128	0.088	0.124	0.104	0.147	0.147	0.225	0.241	0.076	0.203	0.627
Austria	0.147	0.128	**0.130**	0.093	0.144	0.141	0.185	0.137	0.229	0.301	0.286	0.221	0.616
Lithuania	0.128	-0.088	-0.093	**0.134**	0.152	-0.070	-0.119	-0.187	0.221	0.260	-0.137	0.231	0.663
Czech Rep.	-0.054	-0.124	-0.144	-0.152	**0.142**	-0.177	-0.154	-0.177	0.255	0.260	-0.238	0.126	0.746
Netherlands	0.221	-0.104	-0.141	0.070	0.177	**0.180**	0.162	-0.210	0.302	0.347	0.318	0.329	0.710
Poland	0.137	-0.147	-0.185	0.119	0.154	-0.162	**0.210**	-0.248	0.180	0.243	-0.180	0.252	0.638
Germany	0.119	-0.147	-0.137	0.187	0.177	0.210	0.248	**0.282**	0.316	0.304	0.373	0.372	0.774
Spain	-0.227	-0.225	-0.229	-0.221	-0.255	-0.302	-0.180	-0.316	**0.286**	-0.356	-0.144	-0.306	-0.614
Bosnia and Herzegovina	-0.307	-0.241	-0.301	-0.260	-0.260	-0.347	-0.243	-0.304	0.356	**0.297**	-0.289	-0.265	0.454
Denmark	0.292	-0.076	-0.286	0.137	0.238	-0.318	0.180	-0.373	0.144	0.289	**0.361**	0.470	0.806
Switzerland	-0.155	-0.203	-0.221	-0.231	-0.126	-0.329	-0.252	-0.372	0.306	0.265	-0.470	**0.415**	0.695
Turkey	-0.743	-0.627	-0.616	-0.663	-0.746	-0.710	-0.638	-0.774	0.614	-0.454	-0.806	-0.695	**0.799**

The complete evaluation of each laboratory concerning the mean coefficients *di* (equation [11]) and *dij* (equation [12]) is summarised in the *table 6*. In the **diagonal** there are the mean coefficients *di* which express the equivalence with the key comparison reference value. In other cells there are coefficients *dij* which express the equivalence of one laboratory with another laboratory.

Table 6 -The complete evaluation of each laboratory concerning the mean coefficients di and dij

	Switzerland	Czech Rep.	Slovak Rep.	Germany	Lithuania	Netherlands	Poland	Hungary	Austria	Spain	Bosnia and Herzegovina	Denmark	Turkey
Switzerland	**-0.043**	-0.016	-0.021	-0.045	-0.060	-0.063	-0.063	-0.063	-0.069	0.040	-0.085	-0.107	-0.334
Czech Rep.	0.016	**-0.027**	-0.005	-0.029	-0.044	-0.047	-0.047	-0.047	-0.053	0.014	-0.066	-0.075	-0.394
Slovak Rep.	0.021	0.005	**-0.022**	-0.024	-0.039	-0.042	-0.042	-0.042	-0.048	0.019	-0.061	-0.065	-0.389
Germany	0.045	0.029	0.024	**0.002**	-0.015	-0.018	-0.018	-0.018	-0.024	0.043	-0.037	-0.052	-0.365
Lithuania	0.060	0.044	0.039	0.015	**0.017**	-0.003	-0.003	-0.003	-0.009	0.058	-0.022	-0.013	-0.350
Netherlands	0.063	0.047	0.042	0.018	0.003	**0.020**	0.054	0.000	-0.006	0.061	-0.019	-0.018	-0.347
Poland	0.063	0.047	0.042	0.018	0.003	-0.054	**0.020**	0.000	-0.006	0.061	-0.019	0.007	-0.347
Hungary	0.063	0.047	0.042	0.018	0.003	0.000	0.000	**0.020**	-0.006	0.061	-0.019	-0.018	-0.347
Austria	0.069	0.053	0.048	0.024	0.009	0.006	0.006	0.006	**0.026**	0.067	-0.013	-0.002	-0.341
Spain	-0.040	-0.014	-0.019	-0.043	-0.058	-0.061	-0.061	-0.061	-0.067	**0.039**	-0.125	0.008	-0.374
Bosnia and Herzegovina	0.085	0.066	0.061	0.037	0.022	0.019	0.019	0.019	0.013	0.125	**0.039**	-0.058	-0.249
Denmark	0.107	0.075	0.065	0.052	0.013	0.018	-0.007	0.018	0.002	-0.008	0.058	**0.051**	-0.402
Turkey	0.334	0.394	0.389	0.365	0.350	0.347	0.347	0.347	0.341	0.374	0.249	0.402	**0.367**

The error curves of all participants and of the key comparison reference values are summarised in the graph mentioned down.