



**Final Report – Draft B**

**Inter-laboratory calibration comparison  
of the turbine gas meter G6500**

**EURAMET Project No. 1006**



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## 1. Introduction

The project EURAMET no.1006 for the comparison of the axial turbine gas meter G6500 officially started in April 2008 and was concluded in December 2008. The planned time schedule is shown in *table 1*. Each country took two weeks to perform the calibration of the turbine gas meter G6500 with air in the pressure which is close to barometric pressure. The range of flow rates was from 1000 m<sup>3</sup>/h to 10000 m<sup>3</sup>/h. The participating laboratories used their usual calibration procedure. The comparison was conducted with respect to guidelines<sup>1) 2)</sup>.

Two participant of this project Germany (PTB) and Netherlands (VSL) were also participants in the CIPM key comparison CCM.FF-K6 which covers flow rates only up to 260 g/min (approximately 18.7 m<sup>3</sup>/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	1.4.-13.4. 2008	Tomas Valenta
Germany	PTB Physikalisch- Technische Bundesanstalt	PTB Bundesallee 100 38116 Braunschweig Germany	14.4.-27.4. 2008	Bodo Mickan
Spain	CEM (Centro Español de Metrología) Enagas S.A.	Laboratorio Central Enagas Carretera de Madrid, km 306,4 50012 Zaragoza Spain	28.4.-11.5. 2008	Antonio J Puyuelo

<sup>1)</sup> EUROMET Guide No.3 - "Guidelines on Conducting Comparisons"

<sup>2)</sup> Guidelines for CIPM key comparisons  
<http://www.bipm.org/utis/en/pdf/guidelines.pdf>

Country	Laboratory	Address of the place of calibration	Date of calibration	Responsible person
France	LNE-LADG Laboratoire Associé de Débitmétrie Gazeuse	LNE-LADG 43 route de l'Aérodrome 86000 POTIERS FRANCE	12.5.-25.5. 2008	Christophe Windenberger
Netherlands	VSL Nederlands Meetinstituut Van Swinden Laboratorium	VSL Flow Thijsseweg 11 2629JA Delft The Netherlands	26.5.-8.6. 2008	Mijndert P. van der Beek
Denmark	FORCE Technology	FORCE Technology, Vejen, Navervej 1 6600 Vejen Denmark	9.6.-22.6. 2008	Kurt Rasmussen
Finland	Gasum Oy	Gasum Oy, Flow Measurement Laboratory Kiehvantie 89 FIN-45100 Kouvola Finland	23.6.-6.7. 2008	Jukka Villanen
Lithuania	Lithuanian Energy Institute	Lithuanian Energy Institute Heat Equipment Research and Testing Laboratory Breslaujos str. 3, LT-44403 Kaunas-35, Lithuania	7.7.-20.7. 2008	Jurij Tonkonogij
Poland	GUM Główny Urząd Miar (Central Office of Measures)	Central Office of Measures 00-950 Warszawa P-10 ul. Elekoralna 2 Poland	21.7.-3.8. 2008	Monika Kusyk- Ring
Slovak Republic	SMU Slovak Institute of Metrology	SPP-distribúcia a.s. Mlynské nivy 44/b 825 11 Bratislava 26 Slovak Republic	4.8.-17.8. 2008	Stefan Makovnik
Hungary	Hungarian Trade Licensing Office Section of Flow Measurement	Hungarian Trade Licensing Office Section of Flow Measurement H-1124 Budapest Nemetvolgyi ut 37. Hungary.	18.8.-31.8. 2008	Csaba Czibulka
Czech Republic (PILOT LAB)	CMI Czech Metrology Institute	CMI Regional Inspectorate Pardubice Husova 10, 539 73 Skuteč, Czech Republic	1.9.-14.9. 2008	Tomas Valenta

Country	Laboratory	Address of the place of calibration	Date of calibration	Responsible person
Republic of Serbia (ATA-CARNET)	Bureau of Measurements and Precious Metals of Serbia	Bureau of Measurements and Precious Metals, 21 000 Novi Sad, Put Šajkaškog odreda br. 3, Republic of Serbia	15.9.-28.9. 2008	Branislav Tanasić
Turkey (ATA-CARNET)	TUBITAK - UME National Metrology Institute of Turkey	TUBITAK-UME Anibal Cad. TUBITAK Gebze Yerleskesi PK54 - 41470 Gebze-Kocaeli / TURKEY	29.9.-12.10. 2008	Vahit Ciftci
Switzerland (ATA-CARNET)	METAS Metrology and Accreditation Switzerland	Swiss Federal Office of Metrology and Accreditation Lindenweg 50, CH-3003 Bern-Wabern Switzerland	13.10.-26.10. 2008	Hugo Bissig
Czech Republic (PILOT LAB)	CMI Czech Metrology Institute	CMI Regional Inspectorate Pardubice Husova 10, 539 73 Skuteč, Czech Republic	27.10.-9.11. 2008	Tomas Valenta

## 2. The instrument

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

Manufacturer: ELSTER AG Mainz Germany	
EEC type approval: $\mathcal{E}$ D77/721105	$P_{\max}$ : 10 bar
Size: G6500	Inside diameter: DN 400
Serial number: 83001411	Pulse number: 371.20 imp/m <sup>3</sup>
$Q_{\min}$ : 1000 m <sup>3</sup> /h	$Q_{\max}$ : 10000 m <sup>3</sup> /h
Weight: approximately 400 kg	
Maximum pressure loss in $Q_{\max}$ with air ( $\rho=1.2$ kg/m <sup>3</sup> ) : 1200 Pa	

*Figure 1 – Axial turbine gas meter ELSTER G6500*

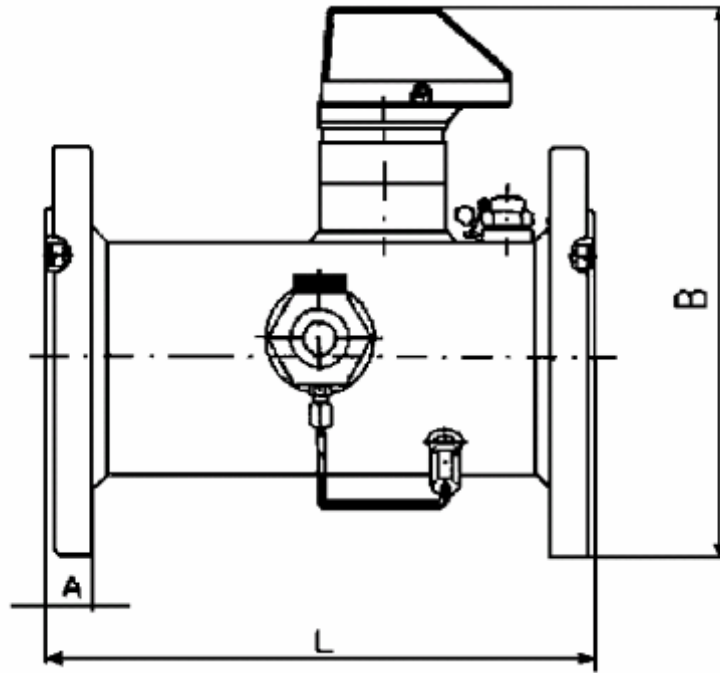


The dimensions of the meter are mentioned in *table 2* and in the *figure 2*.

*Table 2 - Dimensions of the meter*

L	A	B
1200 mm	45 mm	650 mm

*Figure 2 - Dimensions of the meter*



The high frequency pulse emitter A1S was used. This emitter A1S is made according to DIN EN 50227 (NAMUR). The pulse emitter is mentioned in the *figure 3*.

Operating data of the A1S pulse emitter:  
Supply voltage  $U_n = 8 \text{ V DC}$

*Figure 3 – Pulse emitter A1S*





The meter was packed in a wooden box that is mentioned in the *figure 4*. The diameter of the box was (1530 x 970 x 840) mm. The weight of the complete box with the meter was approximately 500 kg. In the wooden box there the gas meter was fastened with two textile slings with ratchets (*figure 5*).

*Figure 4 – The wooden box for the turbine gas meter G6500*



*Figure 5 – Textile slings with ratchets*





In the box there were the meter, chocks, textile slings with ratchets, a pulse emitter connector and the copy of a technical protocol.

### 3. Calibration procedure

The turbine gas meter G6500 was tested with air in the pressure which is close to barometric pressure. The meter was tested in horizontal position in each laboratory. For the tests it was necessary to use the upstream straightening pipe that was long at least 5x DN and the downstream straightening pipe that was long at least 3x DN. The reference pressure from the turbine gas meter was measured from the output “p<sub>r</sub>”. The reference temperature from the turbine gas meter was measured in the distance (2÷3) x DN downstream of the turbine gas meter.

The pulse emitter AIS with the pulse number 371.20 pulses/m<sup>3</sup> was used for the tests. The calibration had to be performed in the laboratory where the temperature was from 19.5°C to 23.5°C. No oil lubrication was used.

The turbine gas meter was tested in 8 flow rates:

10000 m<sup>3</sup>/h, 8000 m<sup>3</sup>/h, 6500 m<sup>3</sup>/h, 5000 m<sup>3</sup>/h, 4000 m<sup>3</sup>/h, 3000 m<sup>3</sup>/h, 2000 m<sup>3</sup>/h, 1000 m<sup>3</sup>/h.

The test was repeated at least 3 times in each flow rate and then the means of values in the *table 3* mentioned down were calculated. The flow rate had to be in the interval ± 3% of the required value.

**Table 3 - Required table of 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 <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)
10000					
8000					
6500					
5000					
4000					
3000					
2000					
1000					

**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.

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

where  $E$  is the error of the meter  
 $V_i$  is the indicated volume by the meter (m<sup>3</sup>)  
 $V_c$  is the real volume which has actually flowed through the meter (m<sup>3</sup>)

## 4. Test facility and obtained results

### 4.1. Germany

#### Description of the Nozzle Test rig

The nozzle test rig (*Fig. 6*) for large gas meters (2 - 5600 m<sup>3</sup>/h) was used for the calibration of the turbine meter G6500 up to a flow rate of 5000 m<sup>3</sup>/h

*Figure 6 - PTB test bench for large gas meters*



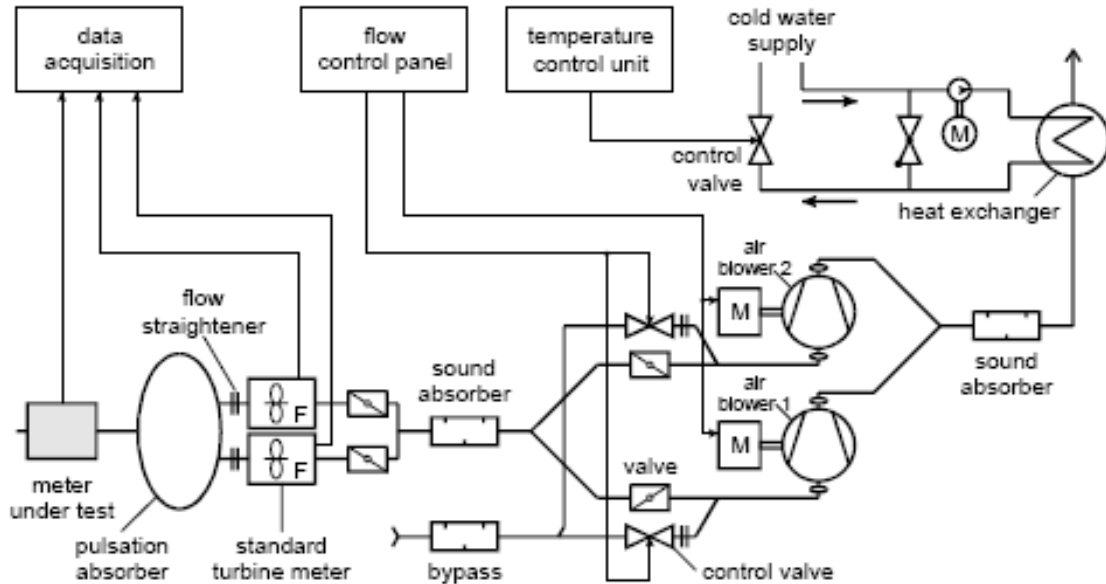
The computer-controlled nozzle test rig consists of an echelon of 16 Venturi nozzles connected in parallel and operated at sound velocity. This mode of operation guarantees a very high stability of the flow rate selected, with short-term reproducibilities of 0.002%. The uncertainty of measurement amounts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

The sonic nozzle test bench is a secondary standard with traceability to the bell prover (1 - 60 m<sup>3</sup>/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.

#### Description of the Turbine Meter Test rig

For the calibration of gas meters of up to 30000 m<sup>3</sup>/h, a test rig (*Fig. 7*) is available which is equipped with two turbine gas meters as standard devices and allows a measurement uncertainty of  $U < 0,12\%$  to be attained. The traceability to the bell prover is given by a scaling procedure via the sonic nozzle test rig described above.

**Figure 7 - PTB turbine meter test rig**



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

Ambient pressure during tests:  $P_{amb} = (1003.3 \div 1008.4)$  mbar

Ambient temperature during tests:  $T_{amb} = (19.91 \div 21.06)$  °C

**Results of PTB:**

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 $U(k=2)$	Reference
(m <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)	
10000	991.02	20.65	not measured	0.144	0.12	Turbines
8000	997.00	20.65	not measured	0.197	0.12	Turbines
6500	1000.83	20.75	not measured	0.195	0.12	Turbines
5000	998.50	19.84	not measured	0.165	0.08	Nozzles
4000	999.86	19.93	not measured	0.135	0.08	Nozzles
3000	1001.42	20.06	not measured	0.110	0.08	Nozzles
2000	1002.78	20.26	not measured	0.117	0.08	Nozzles
1000	1003.11	20.35	not measured	0.253	0.08	Nozzles

## 4.2. 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)

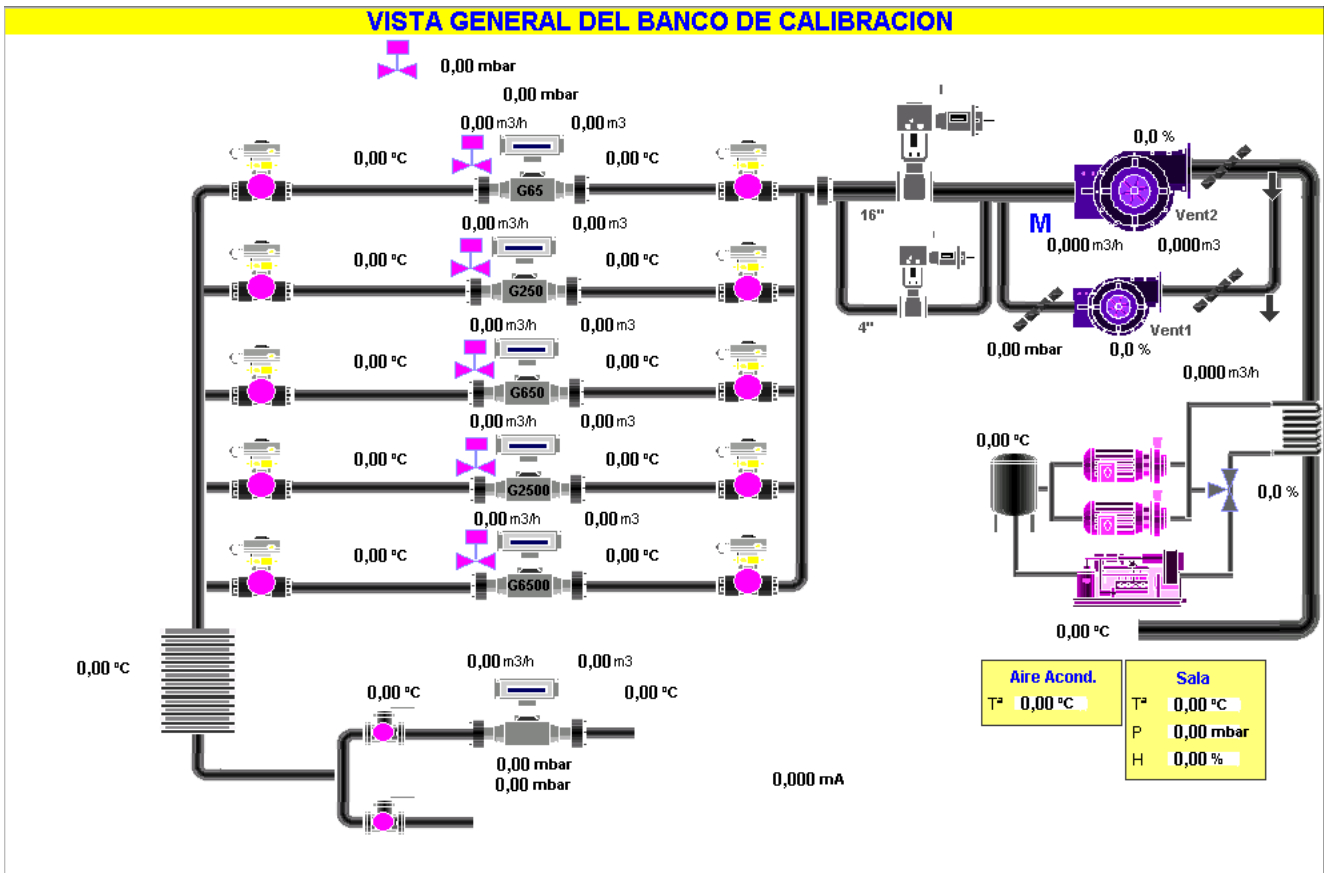
The test bench (as shown in *figures 8 & 9*) consists of five working standard meters, which are periodically calibrated by means of three reference standard meters (with traceability to international standards). Both working and reference meters are described in the following table:

<i>Working Standard Meters</i>			<i>Reference Standard Meters</i>		
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

**Figure 8 - Enagás test bench**



Figure 9 – Enagás test bench diagram



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

The facility is equipped with the necessary equipment for the measurement of gauge and barometric pressure [mbar], temperature [°C], 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.

### 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.
- K factor test: the pulse number per m<sup>3</sup> (K) has been checked before calibration.
- Run-in-period: the meter has undergone a run-in-period of not less than 30 minutes at the flow rate  $Q_{max}$  before calibration.

### Calibration:

Calibration has been carried out with air at a pressure close to atmospheric pressure. The laboratory air temperature was within the range  $20\text{ °C} \pm 1\text{ °C}$ .

The determination of the error of the meter is based on the comparison of the volume of the air indicated by standard meter and of the volume which was indicated by the meter under test after calculations of corrections concerning different temperatures and pressures in the standard meter and in the meter under test.

The reference pressure from the turbine gas meter has been measured from the output “pr”. The pressure loss of the meter has been measured between the output “pr” and the meter outlet. Calibration has been performed by means of the A1S high frequency pulse emitter.

Minimum volumes established for each nominal calibration flow rate were the following (108 second minimum test time):

Flow rate (m <sup>3</sup> /h)	10000	8000	6500	5000	4000	3000	2000	1000
Volume (m <sup>3</sup> )	300	240	195	150	120	90	60	30

Deviation between nominal test flow rates and real test flow rates has been less than  $\pm 3\%$ . 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 the uncertainty of the error.

### Traceability

The results of the calibration services of Enagás (Laboratorio de Contadores de Gas) are traceable to primary and/or (inter)nationally accepted measurement standards.

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:

<i>Item</i>	<i>Traceability</i>	<i>Recalibration Intervals</i>
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	LCOE/USNO	1 year



### Results of Spain:

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 <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)
10000	96466	20.03	163	0.11	0.28
8000	97025	20.01	104	0.05	0.28
6500	97372	20.09	69	0.16	0.28
5000	97658	20.06	43	0.12	0.28
4000	97775	20.08	29	0.09	0.28
3000	97895	19.96	17	0.13	0.27
2000	97980	20.11	9	0.21	0.27
1000	97961	19.99	3	0.26	0.27

### 4.3. France

The pressure test bench (*Fig. 10*) for medium and high flow rates at Poitiers can generate flow rates from 8 m<sup>3</sup>/h to 90000m<sup>3</sup>/h (standard conditions). A set of 12 Venturi nozzles (nominal flow rate: 1.5 to 1000 m<sup>3</sup>.h<sup>-1</sup>.bar<sup>-1</sup>) operating in sonic conditions is used for the determination of the standard mass flow rate. The longest testing pipeline is 50 m long with nominal diameters from DN25 up to DN300. The test pressure range is from 1 bar up to 50 bar (absolute). Compressed dry air stored in a 110 m<sup>3</sup> vessel under 200 bar is used as the test fluid. Possibilities of testing pressure from 50 to 150 bar are also available on request.

The meter under test is placed on a pipeline downstream the set of nozzles. This configuration allows a comparison between the reference and tested device mass flows. The pressure and the temperature can be measured at the level of the meter in test in order to determine the volumetric flow rate going through.

The air coming from a storage vessel (200 bar-110 m<sup>3</sup>) goes through the valves and the heating control system. This adjusts the suitable temperature and pressure upstream the nozzles automatically. The pipe lines bear the reference nozzles chosen according to the flow patterns to be generated for the tests.

These nozzles are traceable to National Standards since they are calibrated with the GDF "Pisc" facility (PVT, time method). In addition, nozzles for flow, pressures determination are measured using Desgranges & Huot weight testers and temperatures are measured using PT100 and thermocouples probes. All the instruments and probes used are traceable to national standards (LNE for pressure and temperature, LCIE for Voltage).

#### Procedure

- The test line comprises a upstream straight length greater than 20D and the downstream straight length greater than 10D
- The temperature was close to room temperature (20±5)°C
- The tests were performed at flow rates in the range of 10 % to 100 % of the maximum flow rate and under an absolute pressure close to 1 bar
- Calculation of the Reynolds number was performed according to an formula

$$Re = \frac{\rho V D}{\mu}$$

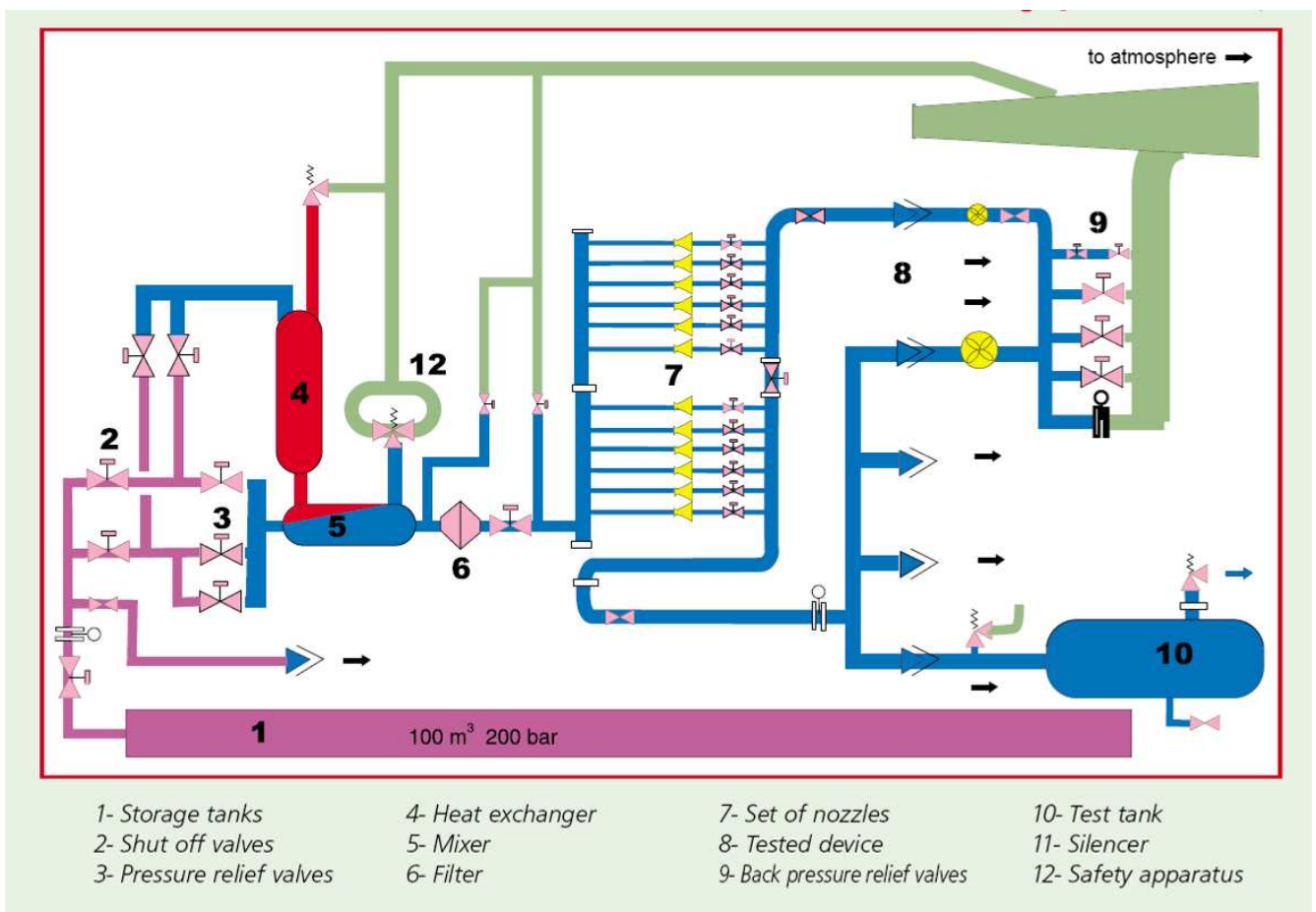
where  $\mu$  is dynamic viscosity which is determined by the Sutherland equation

$$\mu = \mu_0 \sqrt{(T_c/273,15)} \cdot \frac{1 + \frac{120}{273,15}}{1 + \frac{120}{T_c}}$$

$$\mu_0 = 170,8 \cdot 10^{-7} \text{ Pa}\cdot\text{s}$$

where  $T_c$  is the temperature of the air measured downstream from the meter at around  $2D$ .

**Figure 10 – Test bench in Poitiers**



Place of calibration: CESAME LNE ouest - 43, route de l'aérodrome - F - 86036 Poitiers  
Cedex

**Results of France:**

Flow rate	Absolute pressure	Absolute pressure	Temperature	Reynolds Number	Error of the meter	Uncertainty of the error
m <sup>3</sup> /h	bar	Pa	°C		%	%
9949.0	0.99481	99481	17.91	5.820.10 <sup>+05</sup>	-0.13	0.26
7934.2	0.99622	99622	17.24	4.675.10 <sup>+05</sup>	0.02	0.25
6481.1	0.99704	99704	17.50	3.817.10 <sup>+05</sup>	0.05	0.25
5011.7	0.99777	99777	17.68	2.953.10 <sup>+05</sup>	0.14	0.25
4005.6	0.99853	99853	16.91	2.372.10 <sup>+05</sup>	0.08	0.25
2996.1	0.99888	99888	17.88	1.764.10 <sup>+05</sup>	0.06	0.25
2001.1	0.99900	99900	17.84	1.177.10 <sup>+05</sup>	-0.03	0.25
1003.5	0.99899	99899	17.85	5.906.10 <sup>+04</sup>	0.01	0.25

**4.4. Netherlands**

The turbine meter used for this inter-comparison has been calibrated on the ‘Big Installation’ of VSL, located in our lab in Delft, Thijsseweg 11. The installation is made up of two axial blowers, one for low flow rates (up to 4000 m<sup>3</sup>/h) and one for high flow rates (up to 15000 m<sup>3</sup>/h), a regulated heat exchanger after the blowers, data acquisition system, piping, pressure and temperature sensors and five reference meters. The reference meters are described in *table 5*:

**Table 4: Reference meters in big installation in VSL**

Standard nr	Type	Manufacturer	Range
2	G250 IRM-A-DUO rotor meter	Instromet	28 - 400 m <sup>3</sup> /h
3	G650 CVM38M rotor meter	IGA	150 - 1200 m <sup>3</sup> /h
4	G2500 SM-RI-D turbine meter	Instromet	800 - 4000 m <sup>3</sup> /h
5	G4000 SM-RI-D turbine meter	Instromet	1500 - 6500 m <sup>3</sup> /h
6	G6500 SM-RI-D Turbine meter	Instromet	2000 - 9500 m <sup>3</sup> /h

In this inter comparison meter numbers 3, 4, 5 and 6 are used within the range of the Elster turbine meter. When possible overlap measurements between two VSL reference meters has been performed. The reference meters are all traceable to primary and/or (inter) nationally accepted measurement standards. The recalibration interval of the meters is 3 years. The CMC of the installation within the range of 1000 – 10000 m<sup>3</sup>/h is 0.15 %.

The test procedure used by VSL is the test procedure as outlined in the Technical Protocol for EURAMET Project No. 1006. As an addition to this procedure the temperature

of the reference meters and the meter under test is monitored for each flow rate. Once stabilization has occurred, the measurement is started.

**Results of Netherlands:**

Indicated Flow rate	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 <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)
10000	101240	20.4	1212	0.10	0.15
8000	101385	20.3	773	0.15	0.15
6500	101473	20.2	509	0.17	0.15
5000	101543	20.1	299	0.18	0.15
4000	101579	20.1	190	0.17	0.15
3000	101606	20.1	106	0.17	0.15
2000	101625	20.1	46	0.19	0.15
1000	101633	20.0	9	0.42	0.15

## 4.5. Denmark

**Description of the test facilities**

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.C03-001 which is the high-pressure loop. The loop was drained for natural gas and was opened to the ambient and therefore was working with air under atmospheric conditions. The reference meters are calibrated both with air and with natural gas, and FORCE is accredited by DANAC to perform calibration with this loop on air and on natural gas.

During the tests the meter was placed before the working standard (upstream). The air is blown through the meter and the working standards. The pressures at the meter during the tests and at working standards are measured at the  $P_r$ , and temperatures at the meters are measured 2D downstream. The test line consists of 6 working standards in parallel, which all are turbine meters (up 4 working standards are operating at a time). The test line can operate at a flow from 8 m<sup>3</sup>/h to 10000 m<sup>3</sup>/h. The temperature is measured with thermistors, and the pressure is measured with a differential pressure meter between the meter under test and the working standards, and the pressure difference between the meter under test and the barometer reading.

**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, and is as the following, for each test line:

Atmospheric test line C03-001;

$8 < Q < 400 \text{ m}^3/\text{h}$   $U_a \pm 0.24 \%$

$400 < Q < 2000 \text{ m}^3/\text{h}$   $U_a = \pm 0.28 \%$

$2000 < Q < 10000 \text{ m}^3/\text{h}$   $U_a = \pm 0.21 \%$

**Results of Denmark:**

Flow rate	Abs. pressure at the meter	Temperature at the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
[m <sup>3</sup> /h]	[Pa]	[°C]	[Pa]	[%]	[%]
10000	-	20.27	-	0.27	0.21
8000	-	20.46	-	0.28	0.21
6500	-	20.02	-	0.29	0.21
5000	-	19.99	-	0.28	0.21
4000	-	20.02	-	0.26	0.21
3000	-	19.98	-	0.23	0.21
2000	-	19.95	-	0.27	0.22
1000	-	19.95	-	0.47	0.28

**4.6. Finland**

Gasum Oy’s Flow Measurement Laboratory consists of 2 almost identical test benches, the small and the large test bench. The range of small test bench is from 1 m<sup>3</sup>/h to 1000 m<sup>3</sup>/h (DN40-DN150) and the range of the large test bench is from 60 m<sup>3</sup>/h to 10000 m<sup>3</sup>/h (DN200-DN400). The small test bench consists of 3 standard meters: S12 (duo meter, range 1-65 m<sup>3</sup>/h, S14 (turbine meter, range 40-400 m<sup>3</sup>/h and S16 (turbine meter, range 160-1000 m<sup>3</sup>/h. The large test bench consists of 3 standard meters: S24 (turbine meter, range 60-400 m<sup>3</sup>/h, S28 (turbine meter, range 260-2500 m<sup>3</sup>/h and S36 (turbine meter, range 1600-10000 m<sup>3</sup>/h.

In both test benches air is sucked from test room through meter under test and the standard meter by blowers. Both test benches have their own blowers which are situated outside the test room in covered cabin. The speeds of blowers are controlled with frequency converters. The control room is separated from test room with isolates walls.

**Place of the test facility:** Gasum Oy  
Flow Measurement Laboratory  
Kiehuvantie 89,  
FIN-45100 Kouvola

**Traceability:**

<i>Measuring instrument</i>	<i>Number of pieces</i>	<i>Traceable to</i>	<i>Recalibration interval</i>
Standards meters	6	VSL, The Netherlands	3 years/ 2 month (note 1)
Absolute pressure sensors	2	VSL/Mikes	3 years/ 6 month (note 2)
DP sensors	2	VSL/Mikes	3 years/ 6 month (note 3)
Temperature sensors	8	VSL/Inspecta	3 years/ 6 month (note 4)

Note 1: Standards meters, absolute pressure sensors, dp- sensors and temperature sensors and the whole installation are recalibrated with VSL’s travelling reference meters every 3 years. Every 2 month both the test benches are checked with our own travelling meter set (5 meters). After 18 month from VSL’s calibration this travelling meter set is sent to VSL for recalibration.

Note 2: In addition to VSL’s calibration (every 3 years) every 6 month both absolute pressure sensors are calibrated with our own absolute pressure reference (Multifunction Pressure Indicator). This our pressure reference is calibrated once a year at Mikes.

Note 3: In addition to VSL’s calibration (every 3 years) every 6 month both dp- sensors are calibrated with our own absolute pressure reference (Multifunction Pressure Indicator). This our pressure reference is calibrated once a year at Mikes (Centre for Metrology and Accreditation).

Note 4: In addition to VSL’s calibration (every 3 years) every 6 month all temperature sensors are calibrated with our own thermometer reference (Precision Thermometer Set, consists of 6 precision glass thermometers). This our thermometer reference is calibrated once a year at Inspecta ( Accredited Calibration laboratory).

**Test procedure:**

A normal calibration procedure was used with exception of flow rates 8000 m<sup>3</sup>/h and 10000 m<sup>3</sup>/h. In these two flow rates the time of test was 1 minute although during normal procedure less time is used. The test procedure is the traditional master meter method. In this method the gas flow meter to be calibrated is put in series with the standard meter (the meter to be calibrated is situated upstream of the standard meter. Upstream and downstream straightening pipes were 5DN. The test medium was air at near atmospheric pressure. Before the calibration the tightness of the tube system was checked. The meter was calibrated against 2 standard meters (S36 and S28) starting with the largest standard S36. Overlap flow rate was 2000 m<sup>3</sup>/h. Before starting the calibration with the standard meter S28 the meter run at flow rate 1750 m<sup>3</sup>/h for 15 minutes which is normal warm up time for the standard meters. The error and the uncertainty were calculated by the compute software.



### Results of Finland:

Flow rate	Abs. pressure at the meter	Temperature at the meter	Pressure loss of the meter	Error of the meter	Uncertainty of the error U(k=2)
[m <sup>3</sup> /h]	[Pa]	[°C]	[Pa]	[%]	[%]
10000	98165	22.14	-	0.13	0.25
8000	98693	22.19	-	0.15	0.25
6500	99032	22.24	-	0.16	0.25
5000	99319	22.31	-	0.15	0.25
4000	99481	22.35	-	0.11	0.25
3000	99584	22.39	-	0.10	0.25
2000	99669	22.46	-	0.14	0.25
1000	99725	22.51	-	0.44	0.23

## 4.7. 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 turbine 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<sup>3</sup>/h. Methods of calibration».

According to the Technical Protocol for EURAMET Project No. 1006 Inter-laboratory Calibration Comparison of the Turbine Gas Meter» the gas meter has been calibrated at 8 values of flow rate: (10000, 8000, 6500, 5000, 4000, 3000, 2000 and 1000) m<sup>3</sup>/h. Additionally the meter was calibrated at flow rate 1600 m<sup>3</sup>/h

Before the beginning of the test the gas meter worked 20 minutes at flow rate Q=4000 m<sup>3</sup>/h.

The tests were carried out without lubrication of the turbine bears.

Round tubes of diameter DN400 were used as straight pipes. The length of upstream straight pipe was L<sub>1</sub>=3 m (7.5 DN), downstream – L<sub>2</sub>=2 m (5 DN).

The thermometer for measurement of the air flow temperature was installed at the distant of 1.2 m (3 DN) after the meter under test.

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

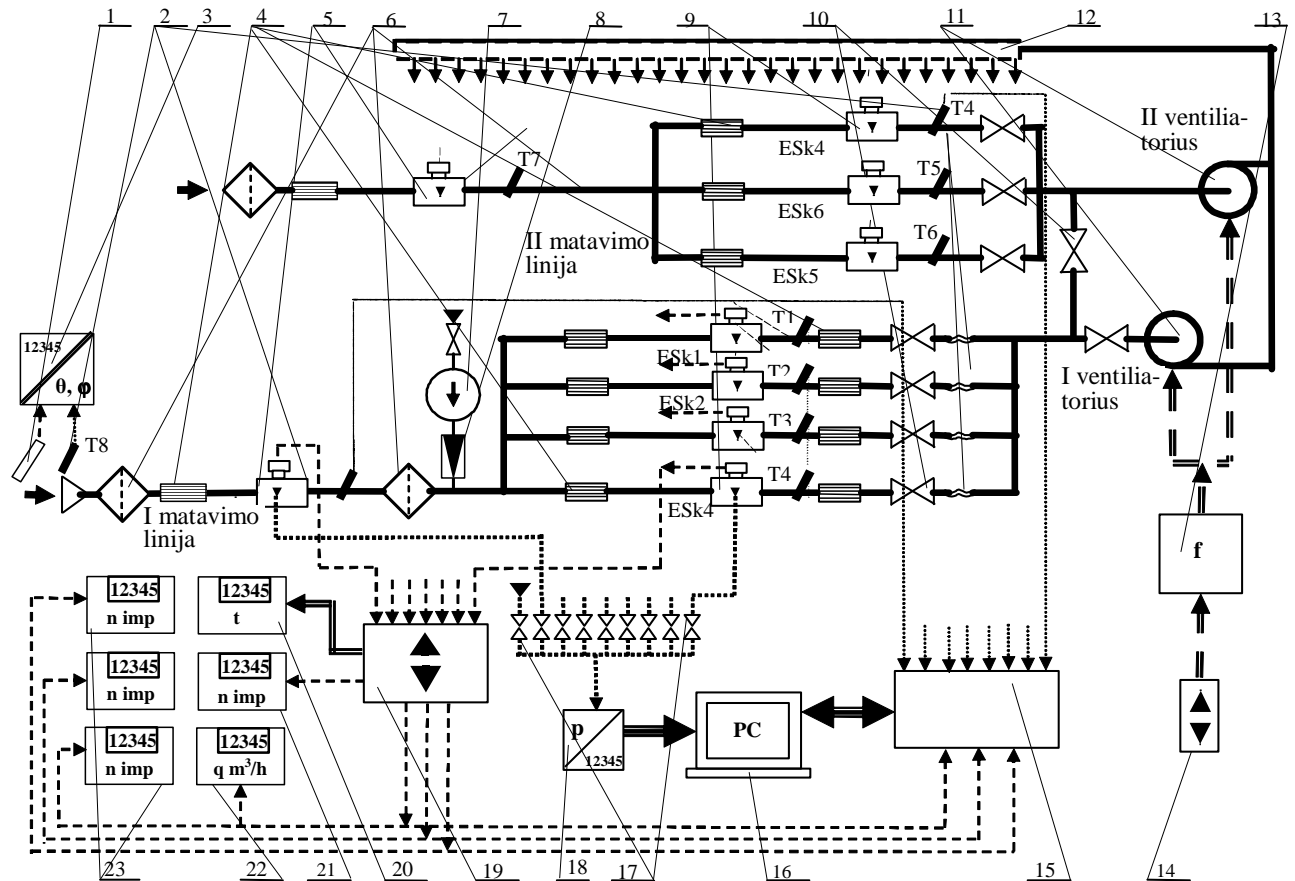
The test at each flow rate was repeated 3 times and then the means values were calculated.

### 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<sup>3</sup>/h, the best measurement capability in the range of flow rate (1600 – 9700) m<sup>3</sup>/h is ± 0,3 %.

The facility was calibrated 11.12.2006, certificate of calibration No. 128/06-L. The scheme of the facility is presented at Fig.11.

**Fig. 11. The scheme of the standard facility. 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 Fig.12.

### Ambient conditions

Atmospheric pressure ( $1012 \pm 4$ ) mbar; temperature ( $21,5 \pm 2$ ) °C; relative air humidity ( $57 \pm 6$ ) %.

### Traceability

Three in parallel connected reference gas meters were used for calibration:

1. Turbine gas meter of SM-RI-X-L type, G4000, DN300,  $Q_{\max} = 6500 \text{ m}^3/\text{h}$ , production of the company “INSTROMET” (Belgium), S/N 70365, calibrated by PTB (Germany), calibration certificate No.07/061/03 of 08.06.2007.
2. Turbine gas meter of CGT-2 type, G1000, DN200,  $Q_{\max} = 1600 \text{ m}^3/\text{h}$  production of the company “COMMON” (Poland), S/N 510136, calibrated by PTB (Germany), calibration certificate No.06/028/03 of 19.04.2006.
3. The reference gas meter of AAT-60 type, DN200,  $Q_{\max} = 1600 \text{ m}^3/\text{h}$ , production of the company “EQUIMETER” (USA), S/N 3099342, calibrated by PTB (Germany), calibration certificate No.04/045/03 of 06.07.2004.

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

*Fig.12. The general view of the standard facility*



### Ambient conditions

Atmospheric pressure ( $1012 \pm 4$ ) mbar; temperature ( $21.5 \pm 2$ ) °C; relative air humidity ( $57 \pm 6$ ) %.

### Traceability

Three in parallel connected reference gas meters were used for calibration:

4. Turbine gas meter of SM-RI-X-L type, G4000, DN300,  $Q_{\max}= 6500 \text{ m}^3/\text{h}$ , production of the company “INSTROMET” (Belgium), S/N 70365, calibrated by PTB (Germany), calibration certificate No.07/061/03 of 08.06.2007.
5. Turbine gas meter of CGT-2 type, G1000, DN200,  $Q_{\max}= 1600 \text{ m}^3/\text{h}$  production of the company “COMMON” (Poland), S/N 510136, calibrated by PTB (Germany), calibration certificate No.06/028/03 of 19.04.2006.
6. The reference gas meter of AAT-60 type, DN200,  $Q_{\max}= 1600 \text{ m}^3/\text{h}$ , production of the company “EQUIMETER” (USA), S/N 3099342, calibrated by PTB (Germany), calibration certificate No.04/045/03 of 06.07.2004.

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

### Results of Lithuania:

Flow rate in the meter	Absolute pressure in the meter	Air temperature downstream	Pressure loss of the meter	Error of the meter	Expanded uncertainty of the error U (k=2)
[m <sup>3</sup> /h]	[kPa]	[°C]	[Pa]	[%]	[%]
9700	99.5±0.6	21.5±2	Not measured	0.01	± 0.31%
7971				0.02	± 0.31%
6511				0.04	± 0.31%
4995				0.06	± 0.31%
3998				0.05	± 0.31%
3002				0.04	± 0.31%
2004				0.10	± 0.31%
1601				0.15	± 0.31%
1006				0.35	± 0.31%

## 4.8. Poland

### Address of the laboratory:

Central Office of Measures (GUM)  
Gas Meters Testing Laboratory  
ul. Elektoralna 2  
00-950 Warsaw, P-10  
Poland

### Test facility: bell prover

$Q_{\min}= 9 \text{ m}^3/\text{h}$ ,  $Q_{\max}= 7000 \text{ m}^3/\text{h}$   
 $V_n = 65 \text{ m}^3$ ,

situated at Central Office of Measures (GUM), Gas Meters Testing Laboratory,  
ul. Elektoralna 2, 00-950 Warsaw P-10, Poland.

**Traceability:** The standard is related to national standards of length, time, pressure, temperature.

**Test procedure:** The calibration of gas meter is carried out by determination of the error-flow rate relationship. Errors of gas meter calibrating are determined by increase of volume measured by gas meter and measurement dose related to gas meter conditions. The volume of gas measured by a gas meter is calculated by multiplying number of high frequency pulses by pulse generator constant.

**Results of Poland:**

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 <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)
10000	x	x	x	x	x
8000	x	x	x	x	x
6500	103407	22.95	x	0.28	0.27
5000	103801	22.88	x	0.15	0.28
4000	103465	22.84	x	0.12	0.27
3000	102965	22.85	x	0.08	0.27
2000	102950	23.11	x	-0.01	0.27
1000	103036	23.10	x	0.24	0.27

**4.9. Slovak republic**

The comparison measurement was realised in the authorised metrological centre AMS SPP-distribúcia, a.s. Bratislava (AMS).

Tests were performed at the standard equipment of Z6, SSPP-10 type with the production number 104/1994. A producer of the equipment is: JUSTUR, s.r.o. Stará Turá, Slovakia. The test fluid: air under atmospheric conditions. The test equipment works in a flow range (25 - 10000) m<sup>3</sup>/h.

**The following standard gas meters have taken part in the measurement:**

- The standard turbine gas meter of the TZ, G6500 size, DN400, produced by: J.B. Rombach, Germany, measuring range (1000 - 10000) m<sup>3</sup>/h, production number 7820043, date of production 1993.

Traceability: In 2005 a calibration of the standard gas meter was realized by the test rig PTB, Germany, with the sign PTB 05. The expanded uncertainty of a measuring is  $U = 0,18 \%$  ( $k = 2$ ) from a measured value of flow. The traceability of standard gas meter is evolved from the primary standard of gas flow rate PTB, Germany.

- The standard turbine gas meter of the TZ, G1600 size, DN250, produced by: J.B. Rombach, Germany, measuring range (250 - 2500) m<sup>3</sup>/h, production number 7602020, date of production 1993.

Traceability: In 2005 a calibration of the standard gas meter was realized by the test rig PTB, Germany, with the sign PTB 05. The expanded uncertainty of a measuring is  $U =$



0,12 % ( $k = 2$ ) from a measured value of flow. The traceability of standard gas meter is evolved from the primary standard of gas flow rate PTB, Germany.

The comparison measurement was realised according to the SMU working procedure No. 11/230/2001, Version 1 and according to the working procedure of testing AMS with markings PPS 5.5-06, Version 2/2008. The SMU title of the working procedure: „Working procedure for calibration, verification and tests for type approvals working on a principle of volume measurement“. The title of the AMS working procedure: „Testing, calibration and verification of industrial gas meters by the test equipment Z6.

The test equipment type SPP-10 during the measurement of comparison is on the following *fig. 13*.

**Figure 13 - Test equipment type SPP-10**



Place of measurement: AMS SPP-distribúcia, a.s. Bratislava  
Testing facility: type SPP-10, Z6  
Atmospheric pressure: 100260 Pa



**Results of Slovak 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 <sup>3</sup> /h]	[Pa]	[°C]	[Pa]	[%]	[%]
10000	99245	21.33	996	0.31	0.35
8000	99599	21.38	641	0.18	0.35
6500	99818	21.37	422	0.27	0.35
5000	99988	21.27	252	0.25	0.35
4000	100078	21.18	162	0.26	0.35
3000	100150	21.12	90	0.21	0.35
2000	100199	21.02	42	0.22	0.35
1000	100229	20.85	11	0.17	0.35

**4.10. Hungary**

**NMI:** MKEH, Hungarian Trade Licensing Office

**The address of the laboratory:**

Flogiston Kft., H-2000 Szentendre, Kőzúzó u. 5.

**The test facility:**

Maximum flow rate: 6000 m<sup>3</sup>/h

Minimum flow rate: 0.5 m<sup>3</sup>/h

Working pressure: atmospheric conditions

Uncertainty (k=2): 0.30 %

**Standard meters:**

No.	Type	Manufacturer	Range
1	AAT-140 / 12” Auto-Adjust Turbo Meter	Equimeter Inc, USA	200 – 4000 m <sup>3</sup> /h
2	AAT-60 / 8” Auto-Adjust Turbo Meter	Equimeter Inc, USA	100 – 1600 m <sup>3</sup> /h
3	AAT-18 / 4” Auto-Adjust Turbo Meter	Equimeter Inc, USA	30 – 500 m <sup>3</sup> /h
4	G40 IRM-A-DUO/50 rotary meter	Instromet	0.5 – 60 m <sup>3</sup> /h

The installation operates 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.

*Fig. 14 Standard meters*



**Traceability:**

The standard meters are traceable 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.

**Description of the test procedure:**

The transfer meter was installed according to the laboratory normal practice and according to the instructions of Project No. 1006. The meter was calibrated against the standard meters Nr.1 and Nr.2. At flow rate 5000 m<sup>3</sup>/h was used both standard meter in parallel.

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 'P<sub>r</sub>' on the transfer meter. The temperature was measured downstream of the transfer meter. The duration of each test was about 100 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 pulse emitter A1S, from the time and from the nominal K-factor (K=371.20 imp/m<sup>3</sup>) of the 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 <sup>3</sup> /h)	(Pa)	(°C)	(Pa)	(%)	(%)
5000	100150	22.4	110	0.07	0.30
4000	100280	22.4	60	0.06	0.30
3000	100410	22.2	35	0.04	0.30
2000	100500	22.0	18	-0.04	0.30
1000	100570	21.7	5	-0.12	0.30

### 4.11. 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 (Fig. 15) consists of 3 standard meters:**

- turbine gas meter G4000 ELSTER s.n. 8311878 calibrated in PTB (Germany) every 5 years in the range (1000-10000) m<sup>3</sup>/h
- turbine gas meter G1000 ELSTER s.n. 83012128 calibrated in PTB (Germany) every 5 years in the range (160-1600) m<sup>3</sup>/h
- positive displacement meter G250 IGA s.n. Y-640 calibrated in CMI (Czech republic) every 2 years in the range (20-400) m<sup>3</sup>/h

The air is sucked from air conditioned laboratory through the meter under test and then through the standard meter. During a test only one standard meter is used. After the temperature stabilisation and after the stabilisation of flow rate the calibration of the meter under test can start. The lowest time of test is 60 seconds if HF pulse emitters are used.

In the laboratory the barometric pressure is measured. The values of temperatures in tapings, which are situated 2xDN downstream of the meters, are measured once a second, too. The values of negative pressures are measured by liquid pressure meter. The 5 complete electronic chains with the temperature sensors Pt100 are regularly calibrated every 2 years by CMI. The pressure meters are calibrated regularly by CMI every 4 years.



*Fig. 15 Test facility in CMI*



### 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 <sup>3</sup> /h]	[Pa]	[°C]	[Pa]	[%]	[%]
10000	95052	23.52	753	0.05	0.19
8000	95590	23.01	500	0.08	0.19
6500	95941	22.18	326	0.09	0.19
5000	96235	21.74	198	0.15	0.19
4000	96381	21.45	131	0.12	0.19
3000	96498	21.58	62	0.05	0.19
2000	96577	21.43	23	0.10	0.19
1000	96635	21.32	10	0.23	0.19

## 4.12. Serbia

### Description of test facilities

Laboratory for gas meters calibration was built in the Republic of Serbia 35 years ago. In the previous period it has been reconstructed and modernized several times. This is the fourth generation (version) of the calibration installation. In all the reconstructions that were made up to now the requirements from OIML Recommendations were used as well as national metrological regulations and experiences of the countries with developed metrological systems.

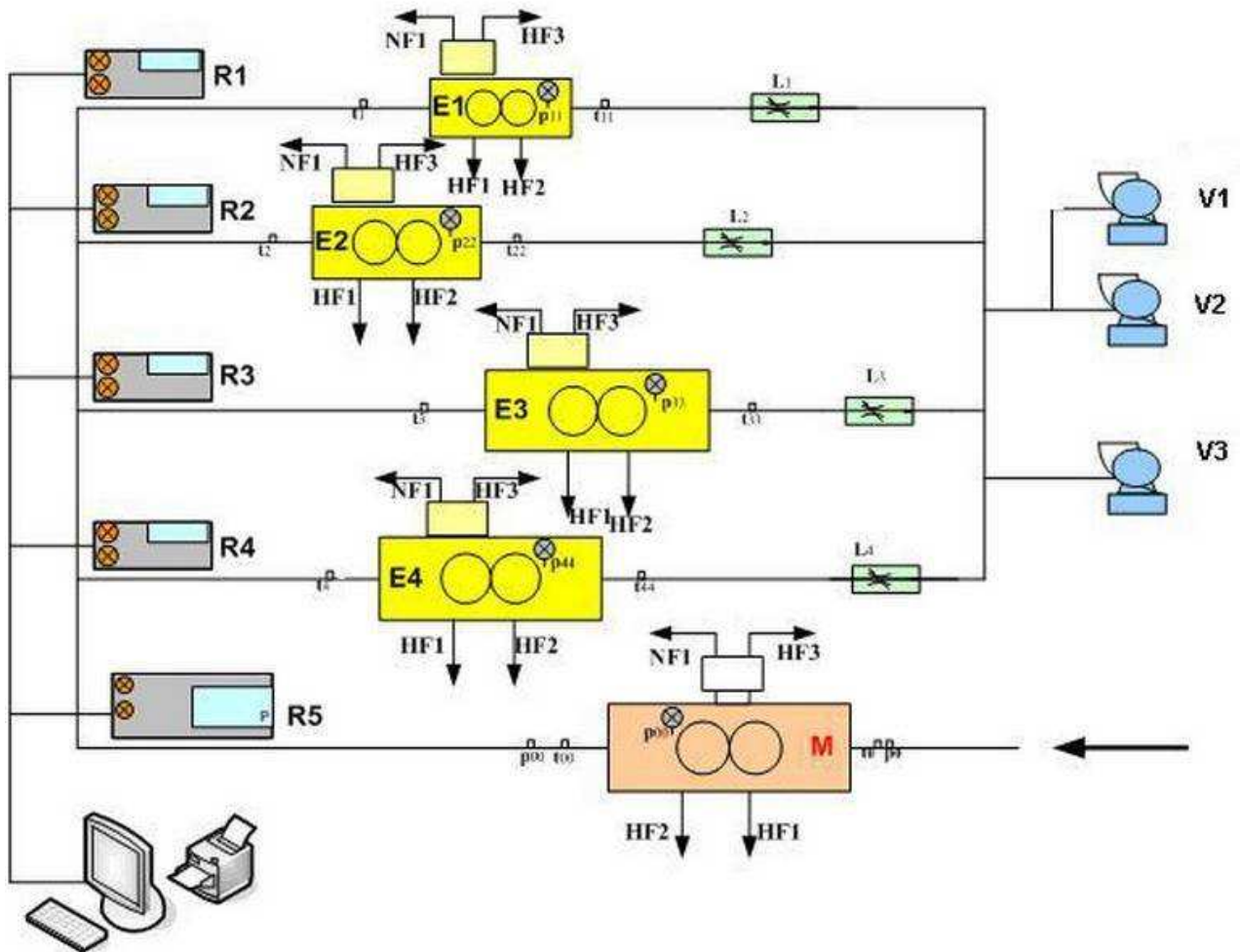
**The address of laboratory:** JP Srbijagas, Merenje i regulacija, Laboratorija za gasnu tehniku, 21000 Novi Sad, Put Šajkaškog odreda 3.

Calibration installation (*Fig. 16*) is located in a building for that purpose with an area of around 1000 m<sup>2</sup>, and the size of the laboratory is 12 m × 8 m × 6 m. In that laboratory the installation for calibration is situated on which the calibration of the turbine gas meter, G-6500 serial number 83001411 was carried out.

The laboratory in which the mentioned sample was tested has air-conditioning and the air temperature which is in the prescribed limits. Outside of the building is a hole with ventilators in which ventilators with electrical motors are situated. Air is pulled in from the laboratory room and so make a flow through the tested gas meter M and corresponding working standard or a combination of working standard.

The testing is carried out with air and at atmospheric pressure. The quantity of air that went through in an interval of time is corrected in relation to pressure and temperature, is brought down to constant conditions and is directly compared, whis results with a relative error of the calibrated meter at the tested point.

Figure 16 - Test facility in Novi Sad



**Note:** During the testing the required straight upstream section length 5xDN was not used.  
 E<sub>1</sub>, E<sub>2</sub>, E<sub>3</sub> and E<sub>4</sub> – Working standards  
 R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> – Working stations,  
 L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> and L<sub>4</sub> – Flow regulators,  
 V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub> – Air ventilators,  
 Central computer and systems for pressure, temperature, and frequency of measurement.

### Traceability of the working standards and other equipment

On the testing installation there are four working standards the characteristics are given in table mentioned down.



	Working standard RE1	Working standard RE2	Working standard RE3	Working standard RE4
<b>Serial number/year of manufacture</b>	48055/1989.	48056/1989.	43779/1987.	43777/1987.
<b>Type and size</b>	SM-RI-K/250; G2500	SM-RI-K/250; G2500	SM-RI-K/200; G1600	SM-RI-K/100; G250
<b>P<sub>max</sub></b>	20 bar	20 bar	20 bar	20 bar
<b>Q<sub>max</sub>/Q<sub>min</sub></b>	4000/200m <sup>3</sup> /h	4000/200m <sup>3</sup> /h	2500/130m <sup>3</sup> /h	400/20m <sup>3</sup> /h
<b>Date of previous calibration</b>	5. nov. 2007.	6. nov. 2007.	6. nov. 2007.	7. nov. 2007.
<b>Place of calibration</b>	Delft VSL	Delft VSL	Delft VSL	Delft VSL
<b>Certificate number</b>	3251819	3251820	3251821	3251822
<b>Manufacturer</b>	Instromet	Instromet	Instromet	Instromet

The process of testing samples is completely automated. The software which manages the testing process is adjusted so that any working standard can be active individually, or in any combination. When all the four working standards are active the installation has a maximum flow of  $Q_{\max} = 10\,000\text{ m}^3/\text{h}$ , and a minimal flow of testing installation is equal to the minimal flow of minimal working standard  $Q_{\min} = 20\text{ m}^3/\text{h}$

Temperature sensors are integrated in every working station. Absolute pressure sensor and differential pressure sensor are integrated in working station R5 which acquires data from the testing example.

### Results of Serbia

Flow rate in the meter (m <sup>3</sup> /h)	Absolute pressure in the meter (Pa)	Temperature in the meter (°C)	Pressure loss of the meter (Pa)	Error of the meter (%)	Uncertainty of the error U (k=2) (%)	Degrees of freedom (1)
10 000	101510	21.9	810	-0.17	0.20	10
8 000	101460	21.8	500	-0.03	0.20	9
6 500	101450	21.9	310	0.02	0.20	11
5 000	101470	21.6	190	0.18	0.20	11
4 000	101460	21.6	110	0.19	0.20	11
3 000	101450	21.6	50	0.08	0.24	11
2 000	101460	21.5	20	0.28	0.24	11
1 000	101490	21.4	10	0.43	0.22	10

Table mentioned down contains basic characteristics of temperature and pressure sensors.

	<b>Absolute pressure sensor</b>	<b>Differential pressure sensor</b>	<b>Temperature sensor</b>
<b>Manufacturer</b>	Energobull, N.Sad	Energobull, N.Sad	Energobull, N.Sad
<b>Measurement range</b>	(800 – 1050) mbar	(0-50) mbar	0-50 °C, with Probe Comeco, type Pt1000, DIN EN 60751. Accuracy of measurement B
<b>Accuracy of measurement</b>	0,15 mbar	0,3 mbar	0,4 °C
<b>Place of installment</b>	Working station R5, No TPC 0998005	Working station R5, No. TPC 0998005, 4 quantity	Working stations on calibration installation, R1,R2,R3,R4 and R5, Serial No. TPC0998001, TPC 0998002, TPC 0998003,TPC 0998004, TPC 0998005
<b>Date of previous calibration</b>	September 2008.	September 2008.	September 2008.
<b>Place of calibration</b>	Customer's laboratory	Customer's laboratory	Customer's laboratory
<b>Standards</b>	1.Barometer Druck, type DPI 740, Ser. No. 74002377, Accuracy $\pm 0,013$ % FS, Resolution 0,01 mbar. 2. Calibrator Druck, type Unomat MCX-II with external pressure sensor, type MCX-PM, Ser. No. 3060, Measurement range (0-360) mbar, Accuracy $\pm 0,1$ mbar $\pm 1$ digit, Resolution 0,01 mbar	Multifunctional Calibrator, Druck, Ser. No. 1052, type UNOMAT MCX-II, with external pressure sensor, type MCX-PM, Ser. No. 3060, Measurement range (0-360) mbar, Accuracy $\pm 0,1$ mbar $\pm 1$ digit, Resolution 0,01 mbar	Dry temperature bath with external Pt - probe: 1. Temperature bath: Manufacturer Druck, Ser. No. 20180, type DBC-150-TC 2. External probe: Manufacturer Elsi s.r.l, Type: B1, Ser. No. E03P154, Measurement range (- 40 to 400) °C, Accuracy: $\pm 0,2$ °C, Resolution: 0,01 °C
<b>Certificate number</b>	1.Barometer Druck, Calibration certificate, Manufacturer Druck, 09. may 2006. 2. Calibration Druck, Certificate No. 004-124-06, 13.02.2006.	Certificate No. 004-124-06, date 13.02.2006.	
<b>Place of standard check</b>	JAT –Tehnika, Belgrade	JAT –Tehnika, Belgrade	

#### 4.13.Turkey

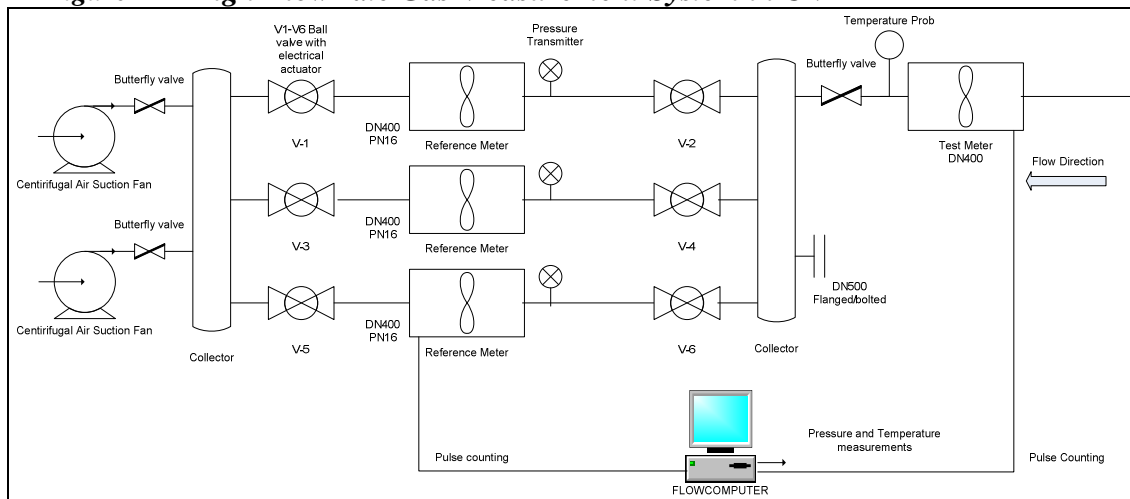
##### UME High Flowrate Gas Measurement System Description:

As seen from the figure given below, UME High Gas Flowrate Measurement System had been designed to operate in the range of 320-19500 m<sup>3</sup>/h for gas flow meter calibrations. It consists of a flow computer, two air suction fans with frequency controller, three parallel

constructed reference flow meters with a same measuring capacity ( $320 \text{ m}^3/\text{h}$  - $6500 \text{ m}^3/\text{h}$ ), upstream and downstream pipes of each flow meter and pressure-actuated ball valves. Time measurement, pulse counts, temperature and pressure measurements of each flow meters are taken by UME flow computer.

Flow meters are traceable to VSL, Netherlands. The total uncertainty of UME High Gas Flow rate Measurement system is about 0.19 % (for  $k=2$ ). The declared expanded uncertainty value is given for  $k=2$  which guarantees the 95% reliability level. Uncertainty is calculated according to GUM, ISO 5168 and EA-4/02 documents. Uncertainty budget consists of the following components; Uncertainty of High Gas Flow Test Rig, Error of Repeatability, Error of Resolution, Temperature measurement, Pressure measurement.

**Figure 17 - High Flow rate Gas Measurement System in UME**



**Figure 18 – Photograph of a tested meter on the line in UME**



**Reference(s) Used in Calibration**

Device	Manufacturer	Type/ Model	Serial number	Traceability Certificate No., Date
Türbinmetre	VemmTec	G4000	31270	UME-G2AG-0070, 08-2008
Türbinmetre	VemmTec	G4000	31268	UME-G2AG-0071, 08-2008
RPM	DH	RPM 1- A0045	54028	UME-G2BA-0010, 02-2008
S10 4WireTermistor Standard	Fluke	1504	3170	NIST Traceable GE Sensing, 16.July.2008
Differential Pressure Gauge	Druck	LPM93 81	17027	UME-G2BA-0069, 06-2007
Temperature &Humudity and Pressure Gauge	Testo	Testo 400	06369741 341853/101- 06369741	UME-G3NM-0076, 05-2008 UME-G2BA-0052, 04-2008

**Calibration Method and Procedure**

Calibration is performed by using the UME standards, turbine meters, under the stable pressure and temperature conditions. The K factor of the transfer turbine meter has been set as 371,2 pulse/m<sup>3</sup> for the pulses transferred from the Body A1S 3&5 signal emitter of the transfer meter to the flow computer. 5DxDN and 3DxDN straightening pipes have been used for upstream and downstream, relatively. The reference pressures from the test and reference gas meters have been measured from the outputs “pr”. The temperature from the test turbine gas meter has been measured in the distance (2÷3)xDN downstream of the turbine gas meter and used for both test and reference meters to calculate standard flow rate values. Pressure loss of the test meter has been taken at the 200mm upstream and downstream distance of the meter. The gas meter has been worked about 30 minutes in nominal flow rate Q=4000 m<sup>3</sup>/h before the beginning of the test. Calibration has been performed in compliance with the UME-TLM-5.4-G2AG-05 “The gas flow meter calibration procedure for high flow rate reference system”

**Environmental Conditions:**

Ambient Temperature: (23.0 ± 1.0) °C

Atmospheric pressure: (996 - 1001) mbar

**Calibration Results of Turkey:**

Calibration has been realized for the range of 1000-10000 m<sup>3</sup>/h by using air in atmospheric pressure. Then, flow rates have been converted to the standard conditions for 1013.25 mbar and 20°C. Transfer meter is called as test meter here.

Relative Error =  $100 \times (\text{Test}(\text{transfer meter}) \text{ standard flow rate} - \text{Reference standard flow rate}) / \text{Reference standard flow rate}$

Ref. std. flow rate	Test std. flow rate	test meter absolute pressure	Test meter temperature	Test meter pressure loss	Relative Error	Uncertainty
(Sm <sup>3</sup> /h )	(Sm <sup>3</sup> /h )	(Pa)	(°C)	(Pa)	(%)	(%)
981.752	987.630	100100	22.3031	14.6	0.599	0.26
1969.932	1976.146	100100	21.9632	49.0	0.315	0.26
2985.148	2996.693	99800	21.9286	112.0	0.387	0.26
3890.881	3908.567	99650	21.7097	180.0	0.455	0.26
4914.262	4934.156	99500	21.7922	299.5	0.405	0.26
6340.040	6363.019	99500	21.4595	495.5	0.362	0.36
7785.188	7804.090	99100	21.6663	730.5	0.243	0.36
9724.738	9753.868	98400	21.6024	1155.0	0.300	0.36

#### 4.14. Switzerland

The test facility is equipped for air flow rates between 0.1 m<sup>3</sup>/h and 4500 m<sup>3</sup>/h and is used for calibration and verifications of gas meters. The air flow is generated by ventilators and measured by secondary standards (turbine gas meters). To achieve this high level of flow rates 6 turbine gas meters are installed as secondary standards.

##### Location:

Federal Office of Metrology METAS  
Laboratory Flow and Volume, Lindenweg 50, CH-3003 Bern-Wabern

##### Traceability

The calibration of the secondary standards (turbine gas meters) is performed by means of the bell prover which is the primary standard.

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.

Calibration interval of the turbine gas meters: 2 years (METAS laboratory gas, bell prover)

Calibration interval of the pressure sensors: 18 month (METAS laboratory pressure)

Calibration interval of the temperature sensors: 18 month (METAS laboratory thermometry)

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 laboratory time and frequency.

### Test procedure

Ambient air is first sucked through the DUT (device under test) and then through the secondary standards of the test facility.

The reference flow rates at the DUT are adjusted by means of the regulation of the rotation speed of the ventilators and the positions of the flap valves.

Once the reference flow rate reaches a steady state, 5 consecutive comparison measurements between the secondary standards and the DUT are performed.

The generated air flow is measured by the secondary standards as volume flow which is then transformed in mass flow by taking into account the pressure, the temperature and the humidity of the air at the secondary standards. 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 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 <sup>3</sup> /h)	(mbar)	(°C)	(mbar)	(%)	(%)
1000.294	94989.90	20.76	-	0.33	0.12
2001.064	94973.32	20.67	-	0.11	0.12
3001.587	94925.16	20.96	-	0.12	0.12
4002.391	94570.60	21.00	-	0.16	0.12

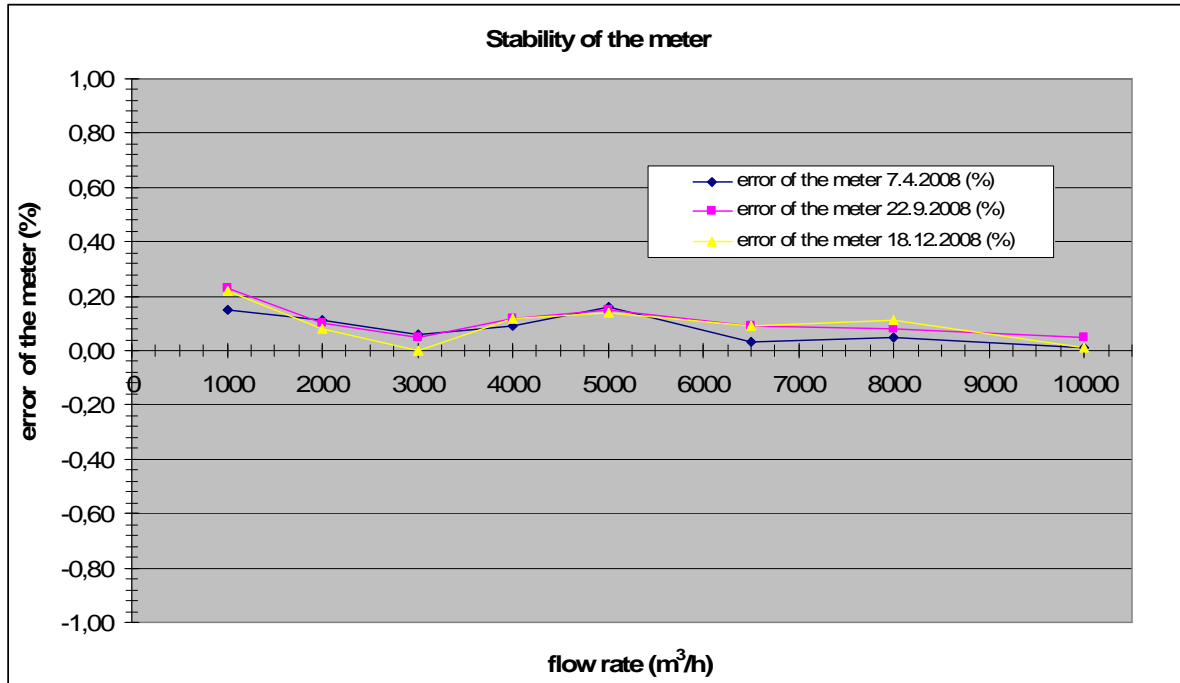
## 5. Stability of the meter and the dependency of laboratories

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

flow rate (m <sup>3</sup> /h)	error of the meter 7.4.2008	error of the meter 22.9.2008	error of the meter 18.12.2008	maximum difference
(m <sup>3</sup> /h)	(%)	(%)	(%)	(%)
10000	0.01	0.05	0.01	0.04
8000	0.05	0.08	0.11	0.06
6500	0.03	0.09	0.09	0.06
5000	0.16	0.15	0.14	0.02
4000	0.09	0.12	0.12	0.03
3000	0.06	0.05	0.00	0.06
2000	0.11	0.10	0.08	0.03
1000	0.15	0.23	0.22	0.08



The estimated standard uncertainty caused by the stability (reproducibility) of the turbine meter is approximately  $u_{tm}=0.023\%$ . In this case the uniform distribution between minimal value and maximal value is assumed.



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

In this project there were 5 laboratories traceable to Netherlands (VSL):  
Denmark, Finland, Hungary, Serbia, Turkey

In this project there were 4 laboratories traceable to Germany (PTB):  
Spain, Czech Republic, Slovak 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<sup>3)</sup>. 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

<sup>3)</sup> Cox M.G., *Evaluation of key comparison data*, Metrologia, 2002, **39**, 589-595

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):

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

where  $x_1, x_2, \dots, x_n$  are errors of the meter in one flow rate in different independent laboratories  $1, 2, \dots, n$   
 $u_{x1}, u_{x2}, \dots, u_{xn}$  are standard uncertainties (not expanded) of the error in different independent laboratories  $1, 2, \dots, n$  including the uncertainty caused by stability of the meter

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

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

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 turbine gas meter (see chapter 5)

The standard uncertainty of the reference value  $u_y$  is given by

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

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

$$U(y) = 2 \cdot u_y \quad [7]$$

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  $\chi_{obs}^2$  was calculated by

$$\chi_{obs}^2 = \frac{(x_1 - y)^2}{u_{x1}^2} + \frac{(x_2 - y)^2}{u_{x2}^2} + \dots + \frac{(x_n - y)^2}{u_{xn}^2} \quad [8]$$

The degrees of freedom  $\nu$  were assigned

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

where  $n$  is number of evaluated laboratories.

The consistency check was failing if

$$Pr\{ \chi_{\nu}^2 > \chi_{obs}^2 \} < 0,05 \quad [10]$$

(The function  $CHIINV(0,05; \nu)$  in MS Excel was used. The consistency check was failing if  $CHIINV(0,05; \nu) < \chi_{obs}^2$ )

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  $\frac{(x_i - y)^2}{u_{xi}^2}$  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  $\chi_{obs}^2$  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

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

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

Based on these differences, the **Degree of Equivalence (DoE)** was calculated according to:

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

and  $Eij = \left| \frac{dij}{U(dij)} \right|$ , respectively. [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  $E_i$  or  $E_{ij} \leq 1$ .
- The laboratory was determined as *not equivalent (failed)* if  $E_i$  or  $E_{ij} > 1.2$ .
- For values of *DoE* in the range  $1 < E_i$  or  $E_{ij} \leq 1.2$  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”<sup>4)</sup>. 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).<sup>5)</sup>

The calculation of the *DoE* needs the information about the uncertainty of the differences  $d_i$  and  $d_{ij}$  (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:

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

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) Differences to the KCRV

##### A1) *Independent laboratories with contribution to the KCRV*

The covariance between the result of a laboratory (with contribution to the KCRV) and the KCRV is the variance of the KCRV itself.<sup>3)</sup>

<sup>4)</sup> 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*,

Both in: D. Richter, W. Wöger, W. Hässelbarth (ed.) *Data analysis of key comparisons*, 178. PTB-Seminar/International Workshop, ISBN 3-89701-933-3.

<sup>5)</sup> 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](http://kcdb.bipm.org/appendixB/appbresults/ccm.ff-k5.b/ccm.ff-k5.b_final_report.pdf)

<sup>3)</sup> Cox M.G., *Evaluation of key comparison data*, *Metrologia*, 2002, **39**, 589-595

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

**A2) Independent laboratories without contribution to the KCRV**

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

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

**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.

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

**B) Differences Lab to Lab**

**B1) Independent laboratories**

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

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

**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  $cov = u_{SourceLab}^2$ .

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

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

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

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

## 6.2. Flow rate 10000 m<sup>3</sup>/h

The first and last round of evaluation in 10000 m<sup>3</sup>/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x^*(1/u)^2$
	(%)	(%)			
Germany	0.1440	0.12851	0.595	242.1894	34.875
Netherlands	0.1000	0.15689	0.005	162.4959	16.250
France	-0.1305	0.26404	2.903	57.3756	-7.487

$$WME = y = 0.094442799$$

$$U(y) = 0.093042282$$

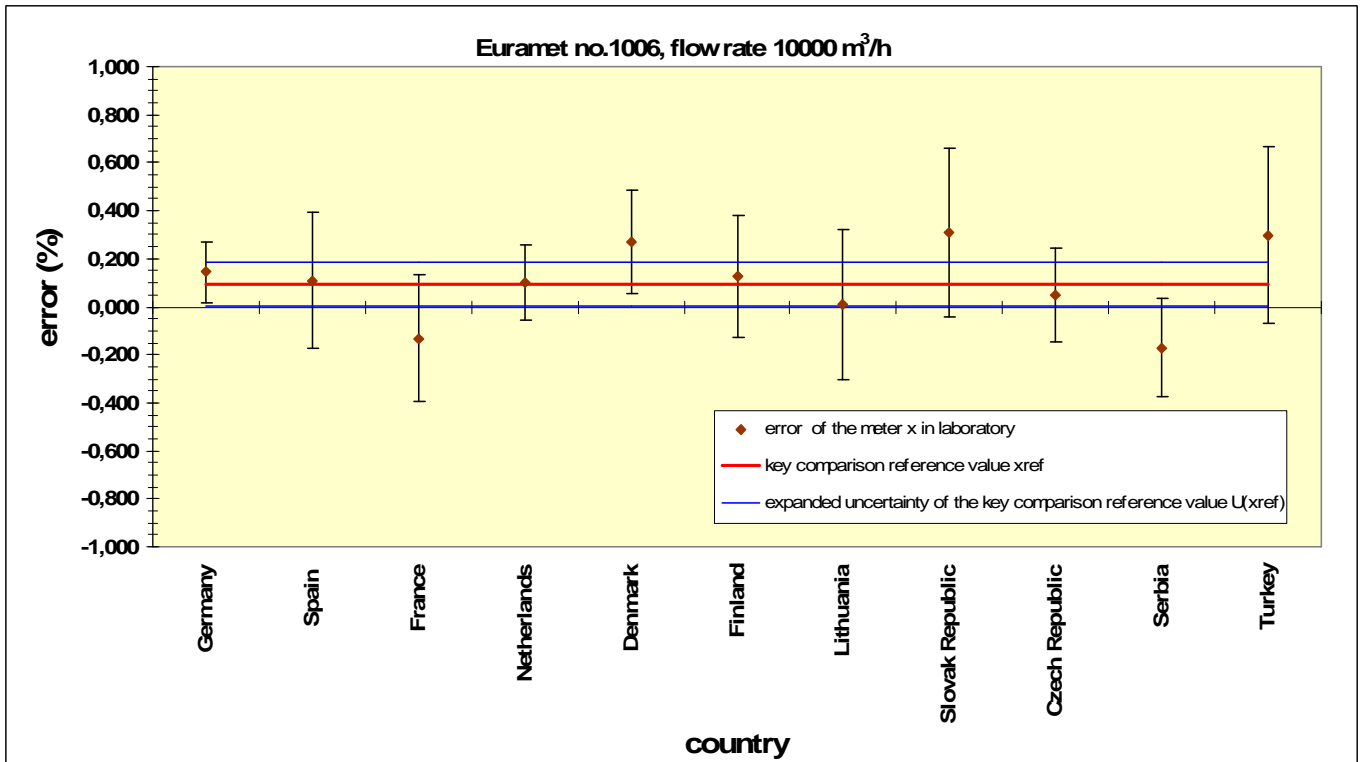
$$CHIINV = 5.991464547$$

$$\chi_{obs}^2 = 3.5025$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)			
Germany	0.144	0.12851	0.05	0.089	0.56
Spain	0.110	0.28375	0.02	0.268	0.06
France	-0.130	0.26404	-0.22	0.247	0.91
Netherlands	0.100	0.15689	0.01	0.126	0.04
Denmark	0.270	0.21498	0.18	0.194	0.91
Finland	0.130	0.25420	0.04	0.237	0.15
Lithuania	0.010	0.31339	-0.08	0.299	0.28
Slovak Republic	0.310	0.35301	0.22	0.341	0.63
Czech Republic	0.050	0.19549	-0.04	0.172	0.26
Serbia	-0.170	0.20522	-0.26	0.183	1.45
Turkey	0.300	0.36610	0.21	0.354	0.58





### 6.3. Flow rate 8000 m<sup>3</sup>/h

The first and last round of evaluation in 8000 m<sup>3</sup>/h:

Country	Error of the meter $x$ (%)	Uncertainty $U(k=2)$ (%)	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x*(1/u)^2$
Germany	0.197	0.128515	0.381	242.19	47.71
Netherlands	0.150	0.156895	0.009	162.50	24.37
France	0.022	0.254197	1.142	61.90	1.33

$$WME = y = 0.157352217$$

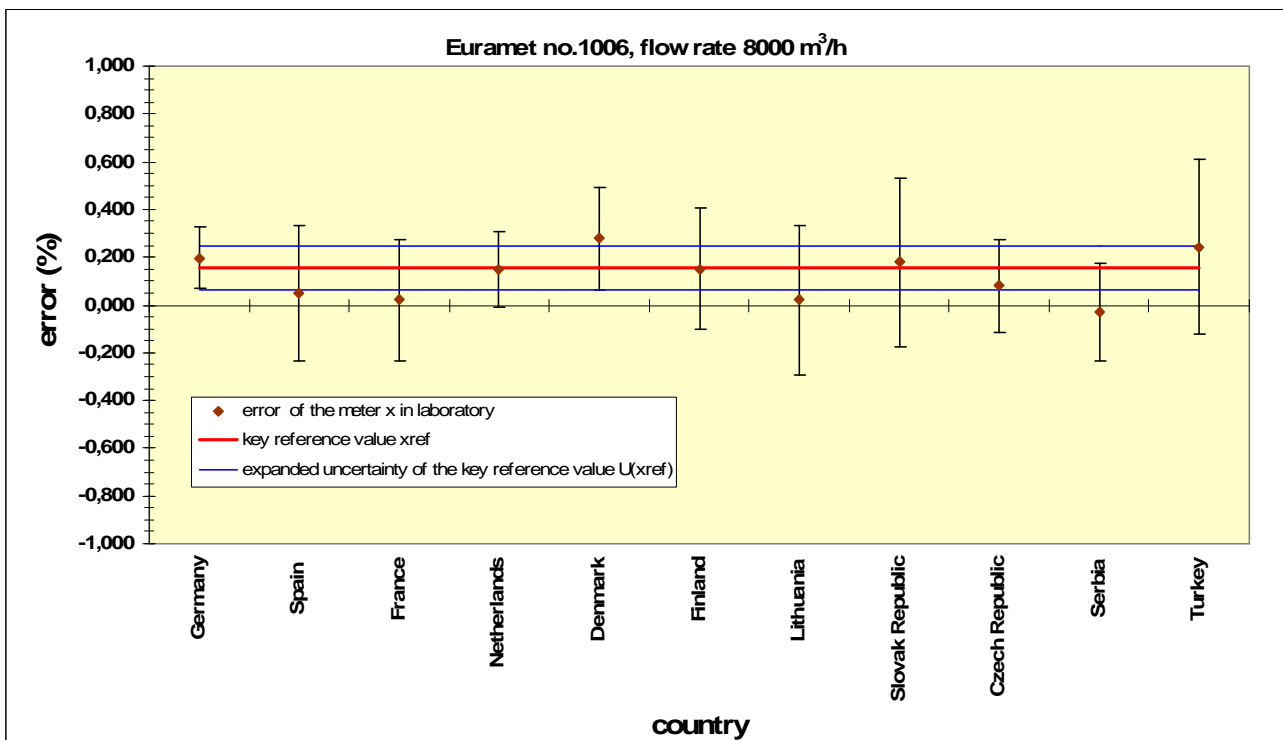
$$U(y) = 0.092589665$$

$$CHIINV = 5.991464547$$

$$\chi_{obs}^2 = 1.5314$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)			
Germany	0.197	0.128515	0.0396	0.089	0.44
Spain	0.050	0.283753	-0.1074	0.268	0.40
France	0.022	0.254197	-0.1358	0.237	0.57
Netherlands	0.150	0.156895	-0.0074	0.127	0.06
Denmark	0.280	0.214979	0.1226	0.194	0.63
Finland	0.150	0.254197	-0.0074	0.237	0.03
Lithuania	0.020	0.313394	-0.1374	0.299	0.46
Slovak Republic	0.180	0.353010	0.0226	0.341	0.07
Czech Republic	0.080	0.195489	-0.0774	0.172	0.45
Serbia	-0.030	0.205222	-0.1874	0.183	1.02
Turkey	0.243	0.366101	0.0854	0.354	0.24



#### 6.4. Flow rate 6500 m<sup>3</sup>/h

The first and last round of evaluation in 6500 m<sup>3</sup>/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x*(1/u)^2$
	(%)	(%)			
Germany	0.195	0.128515	0.061	242.19	47.23
Netherlands	0.170	0.156895	0.014	162.50	27.62
Poland	0.280	0.273890	0.543	53.32	14.93
France	0.054	0.254197	0.967	61.90	3.35

$$WME = y = 0.179133179$$

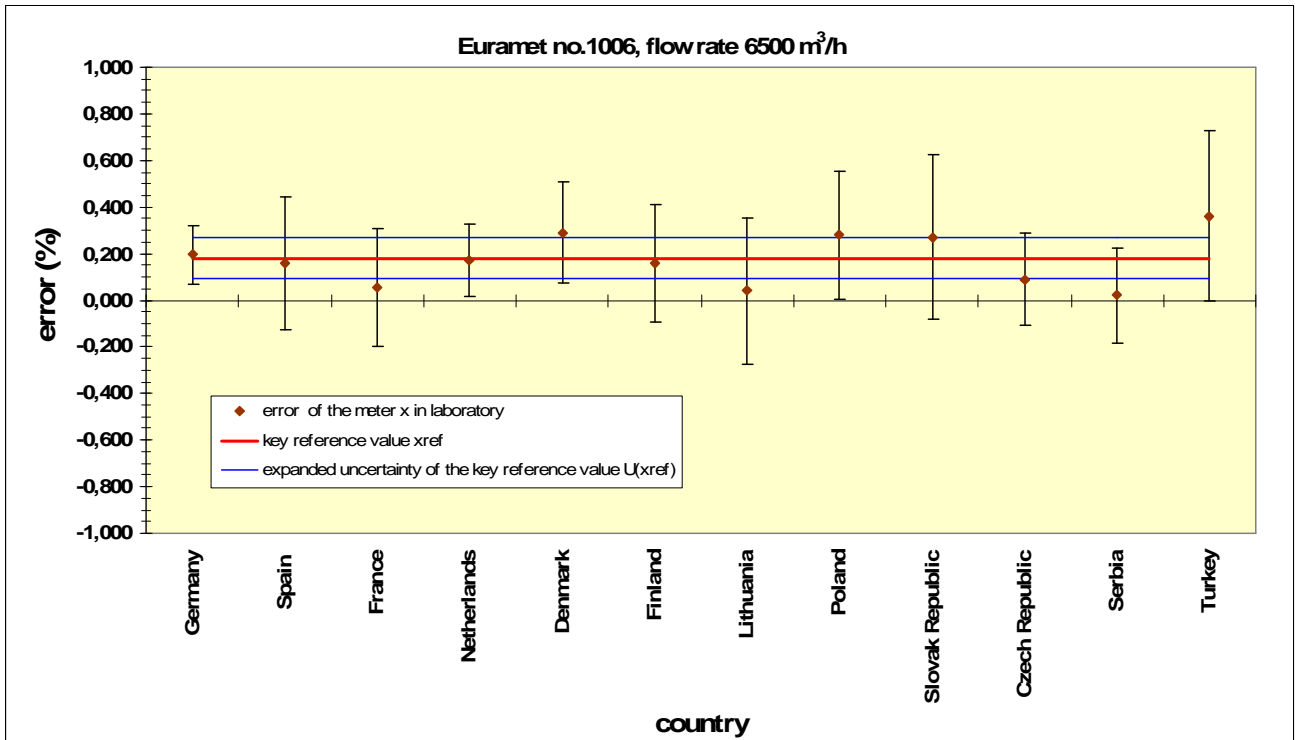
$$U(y) = 0.08771327$$

$$CHIINV 7.814727764$$

$$\chi_{obs}^2 = 1.5841$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)			
Germany	0.195	0.128515	0.0159	0.094	0.17
Spain	0.160	0.283753	-0.0191	0.270	0.07
France	0.054	0.254197	-0.1250	0.239	0.52
Netherlands	0.170	0.156895	-0.0091	0.130	0.07
Denmark	0.290	0.214979	0.1109	0.196	0.56
Finland	0.160	0.254197	-0.0191	0.239	0.08
Lithuania	0.040	0.313394	-0.1391	0.301	0.46
Poland	0.280	0.273890	0.1009	0.259	0.39
Slovak Republic	0.270	0.353010	0.0909	0.342	0.27
Czech Republic	0.090	0.195489	-0.0891	0.175	0.51
Serbia	0.020	0.205222	-0.1591	0.186	0.86
Turkey	0.362	0.366101	0.1833	0.355	0.52



## 6.5. Flow rate 5000 m<sup>3</sup>/h

The first and last round of evaluation in 5000 m<sup>3</sup>/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x*(1/u)^2$
	(%)	(%)			
Germany	0.165	0.0922822	0.000	469.70	77.50
Netherlands	0.180	0.1568949	0.037	162.50	29.25
Poland	0.150	0.2837534	0.011	49.68	7.45
France	0.137	0.2541968	0.049	61.90	8.46

$$WME = y = 0.164915723$$

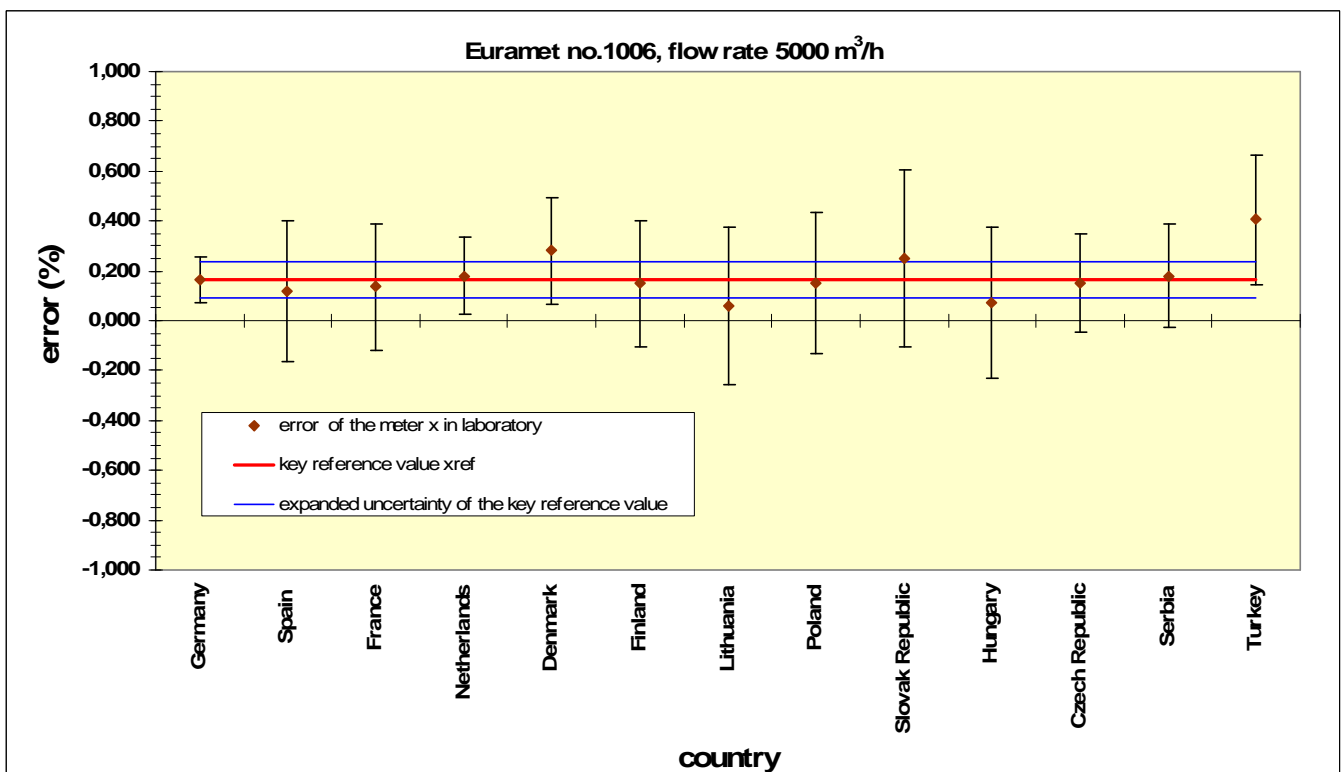
$$U(y) = 0.073334215$$

$$CHIINV = 7.814727764$$

$$\chi_{obs}^2 = 0.0975$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)	(%)	(%)	
Germany	0.165	0.0922822	0.0001	0.056	0.00
Spain	0.120	0.2837534	-0.0449	0.274	0.16
France	0.137	0.2541968	-0.0283	0.243	0.12
Netherlands	0.180	0.1568949	0.0151	0.139	0.11
Denmark	0.280	0.2149791	0.1151	0.202	0.57
Finland	0.150	0.2541968	-0.0149	0.243	0.06
Lithuania	0.060	0.3133943	-0.1049	0.305	0.34
Poland	0.150	0.2837534	-0.0149	0.274	0.05
Slovak Republic	0.250	0.3530099	0.0851	0.345	0.25
Hungary	0.070	0.3035062	-0.0949	0.295	0.32
Czech Republic	0.150	0.1954891	-0.0149	0.181	0.08
Serbia	0.180	0.2052218	0.0151	0.192	0.08
Turkey	0.405	0.2617734	0.2399	0.251	0.95



## 6.6. Flow rate 4000 m<sup>3</sup>/h

The first and last round of evaluation in 4000 m<sup>3</sup>/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x*(1/u)^2$
	(%)	(%)			
Germany	0.135	0.09228	0.031	469.70	63.41
Netherlands	0.170	0.15689	0.117	162.50	27.62
Poland	0.120	0.27389	0.028	53.32	6.40
Switzerland	0.162	0.12851	0.085	242.19	39.21
France	0.081	0.25420	0.242	61.90	4.99

$$WME = y = 0.143113093$$

$$U(y) = 0.063576518$$

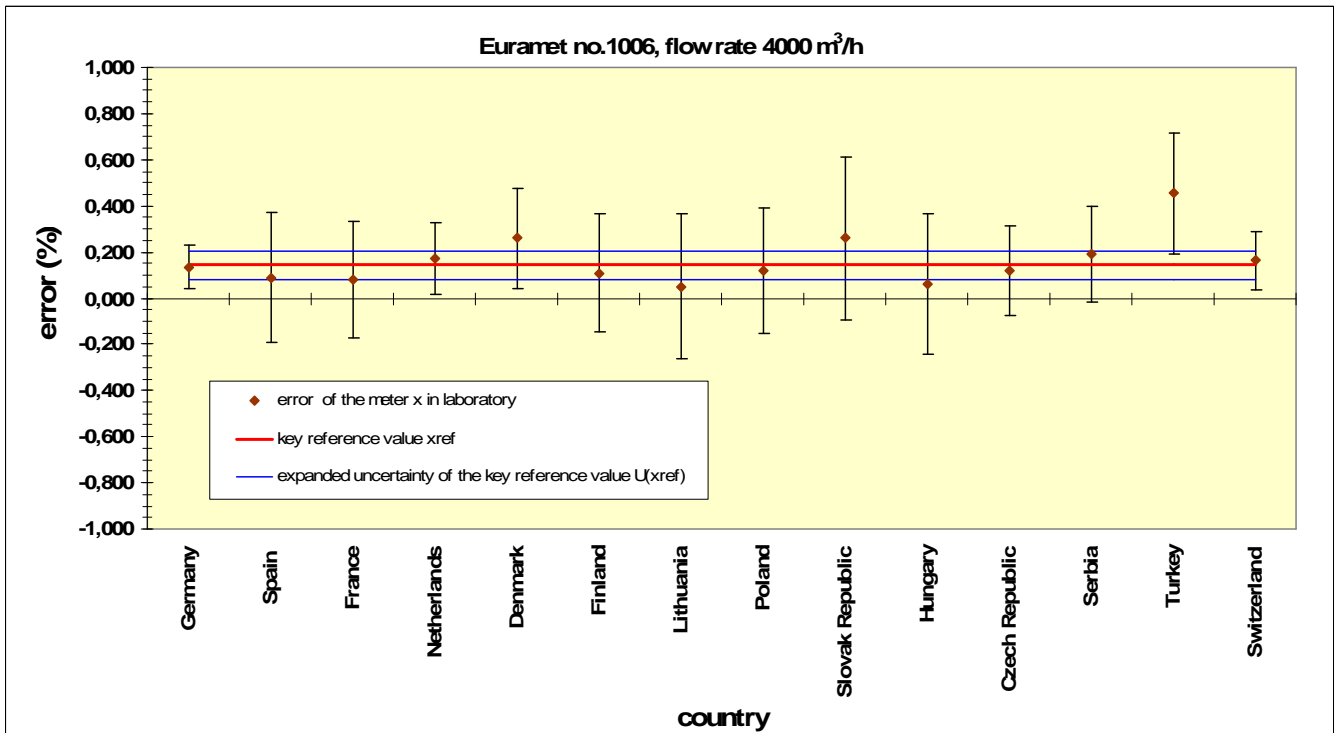
$$CHIINV = 9.487729037$$

$$\chi_{obs}^2 = 0.5045$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)	(%)	(%)	
Germany	0.135	0.09228	-0.0081	0.067	0.12
Spain	0.090	0.28375	-0.0531	0.277	0.19
France	0.081	0.25420	-0.0626	0.246	0.25
Netherlands	0.170	0.15689	0.0269	0.143	0.19
Denmark	0.260	0.21498	0.1169	0.205	0.57
Finland	0.110	0.25420	-0.0331	0.246	0.13
Lithuania	0.050	0.31339	-0.0931	0.307	0.30
Poland	0.120	0.27389	-0.0231	0.266	0.09
Slovak Republic	0.260	0.35301	0.1169	0.347	0.34
Hungary	0.060	0.30351	-0.0831	0.297	0.28
Czech Republic	0.120	0.19549	-0.0231	0.185	0.13
Serbia	0.190	0.20522	0.0469	0.195	0.24
Turkey	0.455	0.26187	0.3114	0.254	1.23
Switzerland	0.162	0.12851	0.0188	0.112	0.17





### 6.7. Flow rate 3000 m<sup>3</sup>/h

The first and last round of evaluation in 3000 m<sup>3</sup>/h:

Country	Error of the meter x	Uncertainty U(k=2)	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	1/u <sup>2</sup>	x*(1/u) <sup>2</sup>
	(%)	(%)			
Germany	0.110	0.09228	0.021	469.70	51.67
Netherlands	0.170	0.15689	0.463	162.50	27.62
Poland	0.080	0.27389	0.072	53.32	4.27
Switzerland	0.116	0.12851	0.000	242.19	28.02
France	0.062	0.25420	0.183	61.90	3.85

$$WME = y = 0.116638324$$

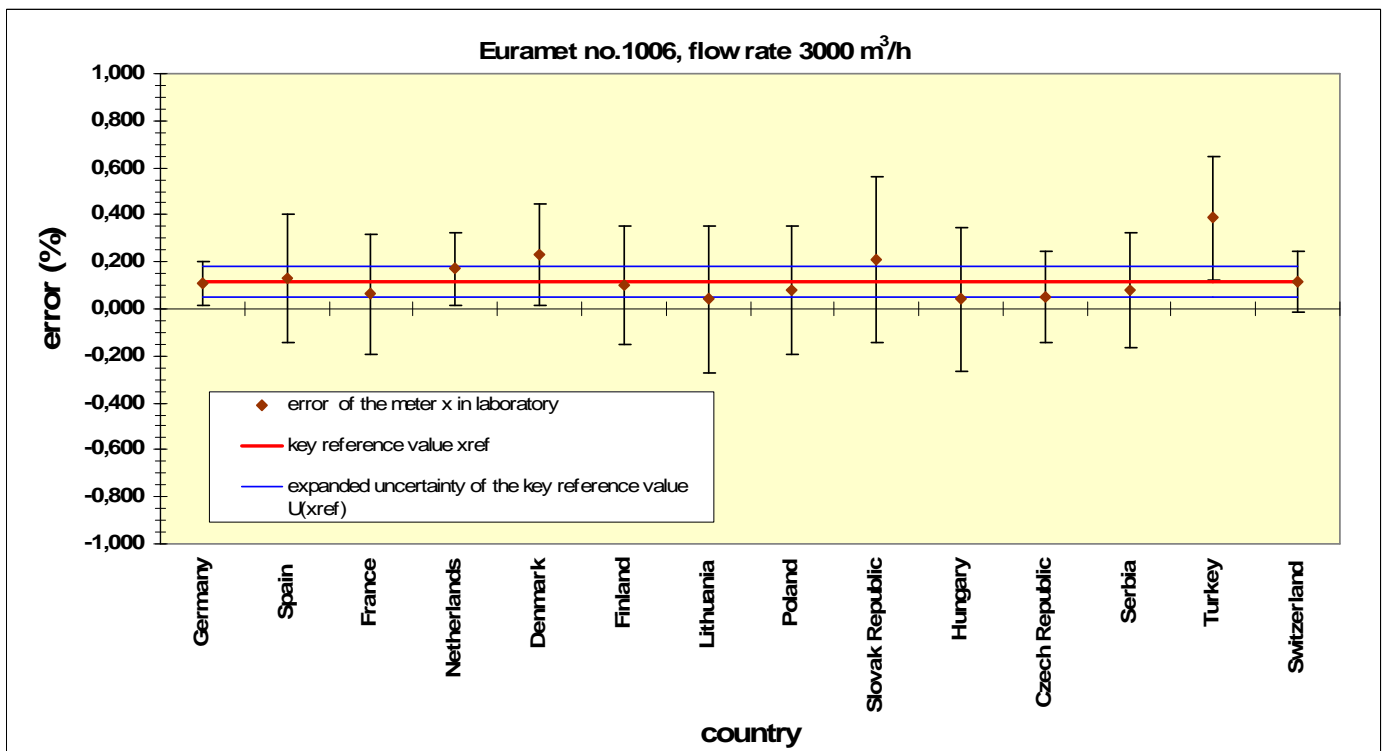
$$U(y) = 0.063576518$$

$$CHIINV = 9.487729037$$

$$\chi_{obs}^2 = 0.7387$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)			
Germany	0.110	0.09228	-0.0066	0.067	0.10
Spain	0.130	0.27389	0.0134	0.266	0.05
France	0.062	0.25420	-0.0544	0.246	0.22
Netherlands	0.170	0.15689	0.0534	0.143	0.37
Denmark	0.230	0.21498	0.1134	0.205	0.55
Finland	0.100	0.25420	-0.0166	0.246	0.07
Lithuania	0.040	0.31339	-0.0766	0.307	0.25
Poland	0.080	0.27389	-0.0366	0.266	0.14
Slovak Republic	0.210	0.35301	0.0934	0.347	0.27
Hungary	0.040	0.30351	-0.0766	0.297	0.26
Czech Republic	0.050	0.19549	-0.0666	0.185	0.36
Serbia	0.080	0.24437	-0.0366	0.236	0.16
Turkey	0.387	0.26197	0.2701	0.254	1.06
Switzerland	0.116	0.12851	-0.0009	0.112	0.01



## 6.8. Flow rate 2000 m<sup>3</sup>/h

The first and last round of evaluation in 2000 m<sup>3</sup>/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x*(1/u)^2$
	(%)		(%)		
Germany	0.117	0.092282	0.010	469.70	54.96
Netherlands	0.190	0.156895	0.978	162.50	30.87
Poland	-0.010	0.273890	0.799	53.32	-0.53
Switzerland	0.115	0.128515	0.001	242.19	27.75
France	-0.029	0.254197	1.241	61.90	-1.81

$$WME = y = 0.11240304$$

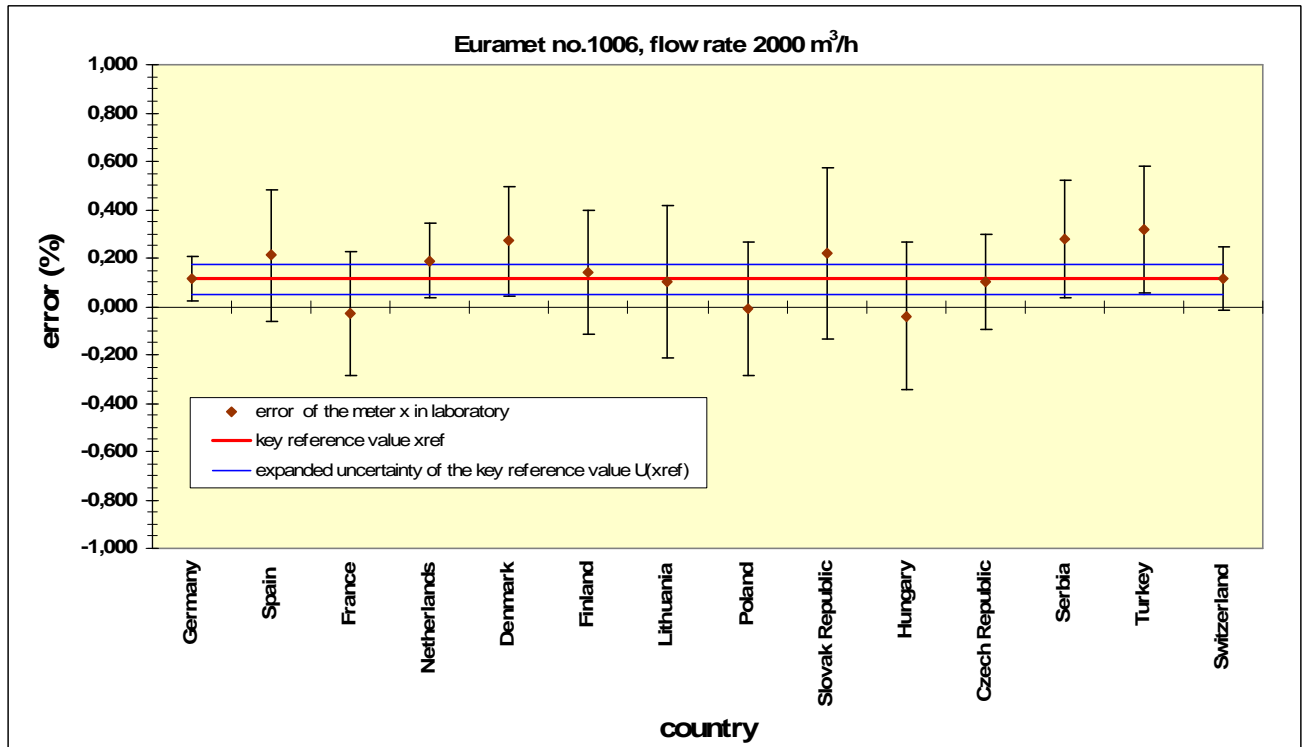
$$U(y) = 0.063576518$$

$$CHIINV = 9.487729037$$

$$\chi_{obs}^2 = 3.0298$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$d_i$	$U(d_i)$	$E_i$
	(%)	(%)			
Germany	0.117	0.092282	0.0046	0.067	0.07
Spain	0.210	0.273890	0.0976	0.266	0.37
France	-0.029	0.254197	-0.1416	0.246	0.58
Netherlands	0.190	0.156895	0.0776	0.143	0.54
Denmark	0.270	0.224758	0.1576	0.216	0.73
Finland	0.140	0.254197	0.0276	0.246	0.11
Lithuania	0.100	0.313394	-0.0124	0.307	0.04
Poland	-0.010	0.273890	-0.1224	0.266	0.46
Slovak Republic	0.220	0.353010	0.1076	0.347	0.31
Hungary	-0.040	0.303506	-0.1524	0.297	0.51
Czech Republic	0.100	0.195489	-0.0124	0.185	0.07
Serbia	0.280	0.244369	0.1676	0.236	0.71
Turkey	0.315	0.262069	0.2031	0.254	0.80
Switzerland	0.115	0.128515	0.0022	0.112	0.02



## Flow rate 1000 m³/h

### The first and last round of evaluation in 1000 m³/h:

Country	Error of the meter $x$	Uncertainty $U(k=2)$	$\frac{(x_i - y)^2}{\left(\frac{U(x_i)}{2}\right)^2}$	$1/u^2$	$x^*(1/u)^2$
	(%)	(%)			
Germany	0.253	0.092282	0.456	469.70	118.84
Netherlands	0.420	0.156895	2.999	162.50	68.25
Poland	0.240	0.273890	0.104	53.32	12.80
Switzerland	0.333	0.128515	0.567	242.19	80.53
France	0.013	0.254197	4.562	61.90	0.79

$$WME = y = 0.284150983$$

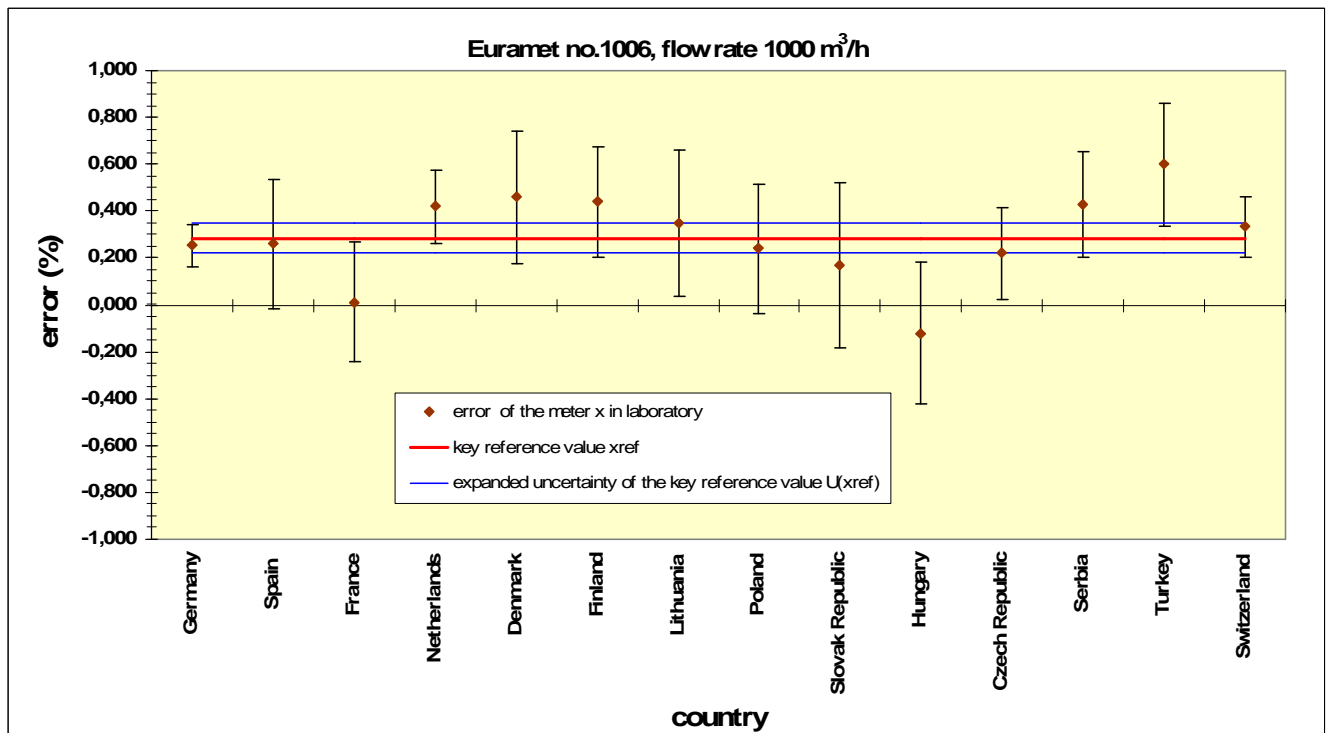
$$U(y) = 0.063576518$$

$$CHIINV = 9.487729037$$

$$\chi_{obs}^2 = 8.6874$$

The consistency check passed because  $CHIINV > \chi_{obs}^2$

Country	Error of the meter $x$ (%)	Uncertainty $U(k=2)$ (%)	$d_i$	$U(d_i)$	$E_i$
Germany	0.253	0.092282	-0.0312	0.067	0.47
Spain	0.260	0.273890	-0.0242	0.266	0.09
France	0.013	0.254197	-0.2715	0.246	1.10
Netherlands	0.420	0.156895	0.1358	0.143	0.95
Denmark	0.460	0.283753	0.1758	0.277	0.64
Finland	0.440	0.234555	0.1558	0.226	0.69
Lithuania	0.350	0.313394	0.0658	0.307	0.21
Poland	0.240	0.273890	-0.0442	0.266	0.17
Slovak Republic	0.170	0.353010	-0.1142	0.347	0.33
Hungary	-0.120	0.303506	-0.4042	0.297	1.36
Czech Republic	0.230	0.195489	-0.0542	0.185	0.29
Serbia	0.430	0.224758	0.1458	0.216	0.68
Turkey	0.599	0.261773	0.3146	0.254	1.24
Switzerland	0.333	0.128515	0.0484	0.112	0.43

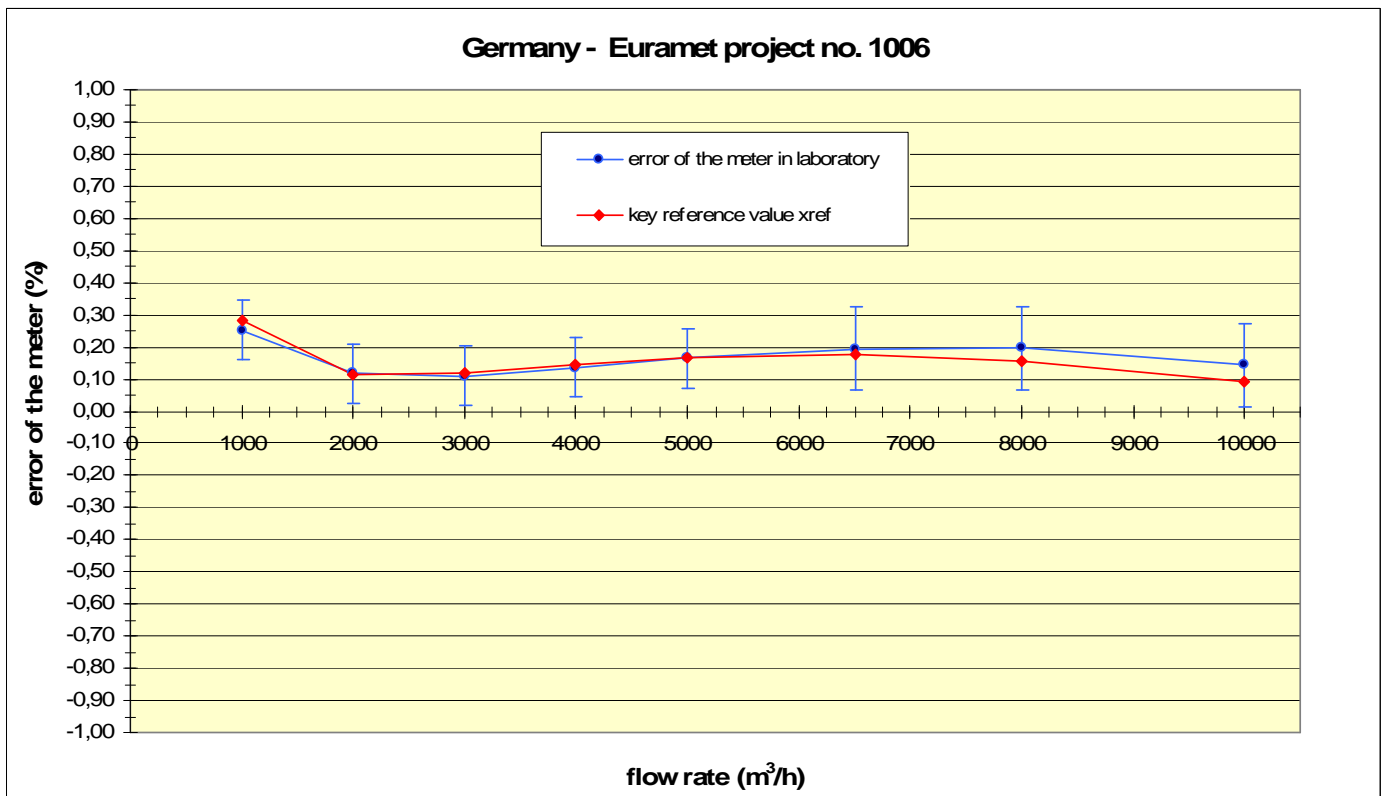


## 7. Results

### 7.1. Independent laboratories

#### 7.1.1. Germany

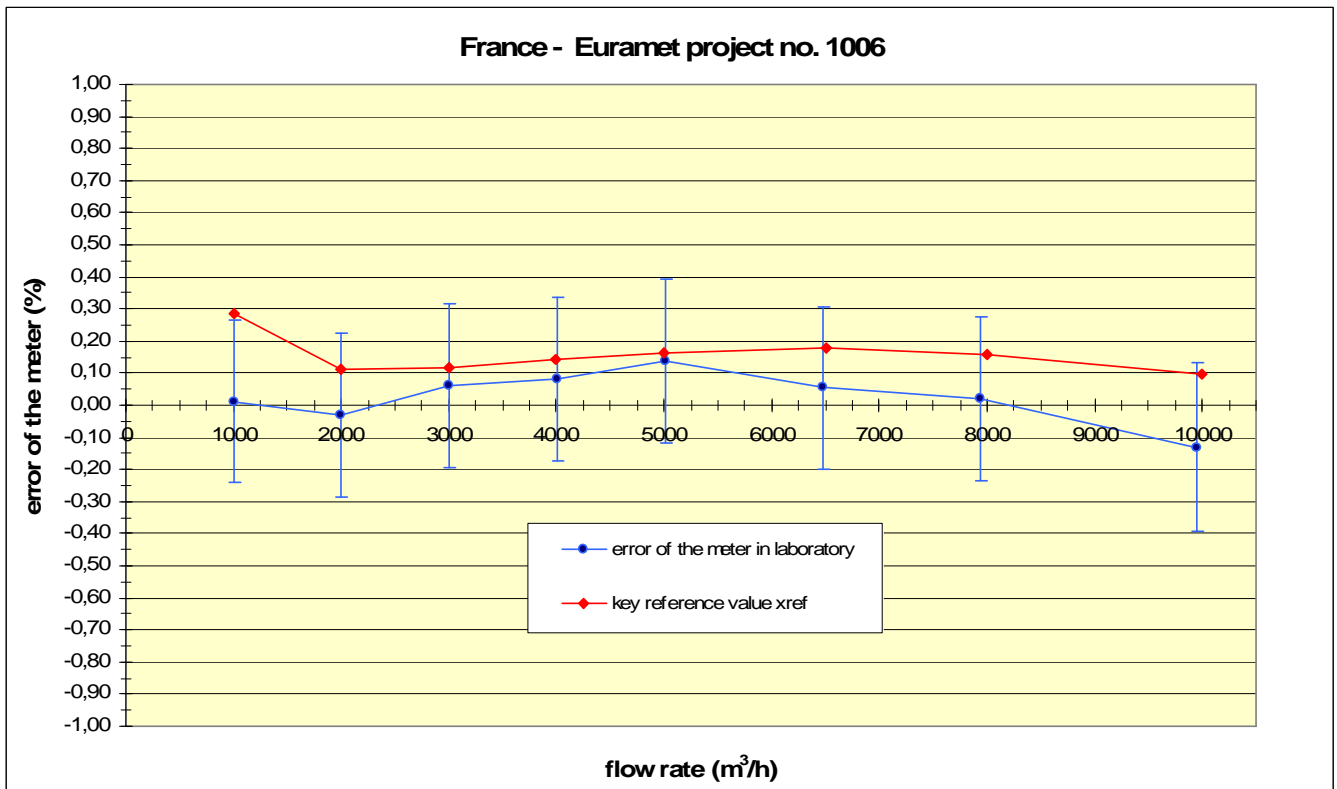
flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	consistency check	di	Ei	result
m <sup>3</sup> /h	%	%	%	%				
10000	0.144	0.129	0.094	0.093	inside	0.05	0.56	passed
8000	0.197	0.129	0.157	0.093	inside	0.04	0.44	passed
6500	0.195	0.129	0.179	0.088	inside	0.02	0.17	passed
5000	0.165	0.092	0.165	0.073	inside	0.00	0.00	passed
4000	0.135	0.092	0.143	0.064	inside	-0.01	0.12	passed
3000	0.110	0.092	0.117	0.064	inside	-0.01	0.10	passed
2000	0.117	0.092	0.112	0.064	inside	0.00	0.07	passed
1000	0.253	0.092	0.284	0.064	inside	-0.03	0.47	passed
					<b>mean</b>	<b>0.01</b>	<b>0.24</b>	<b>passed</b>





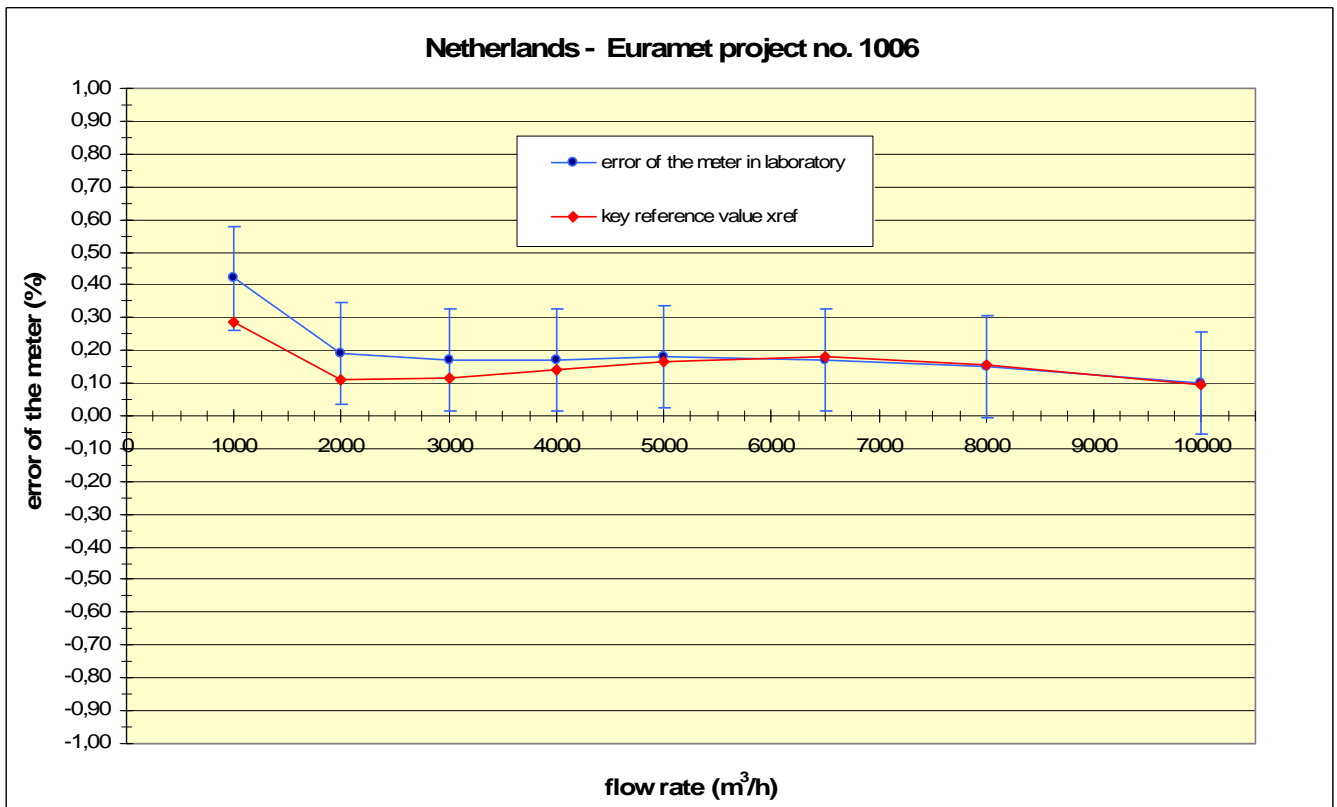
### 7.1.2. France

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	consistency check	di	Ei	result
m <sup>3</sup> /h	%	%	%	%				
9949.04	-0.130	0.264	0.094	0.093	inside	-0.22	0.91	passed
7934.17	0.022	0.254	0.157	0.093	inside	-0.14	0.57	passed
6481.11	0.054	0.254	0.179	0.088	inside	-0.12	0.52	passed
5011.75	0.137	0.254	0.165	0.073	inside	-0.03	0.12	passed
4005.59	0.081	0.254	0.143	0.064	inside	-0.06	0.25	passed
2996.11	0.062	0.254	0.117	0.064	inside	-0.05	0.22	passed
2001.10	-0.029	0.254	0.112	0.064	inside	-0.14	0.58	passed
1003.48	0.013	0.254	0.284	0.064	inside	-0.27	1.10	warning
<b>mean</b>						<b>-0.13</b>	<b>0.53</b>	<b>passed</b>



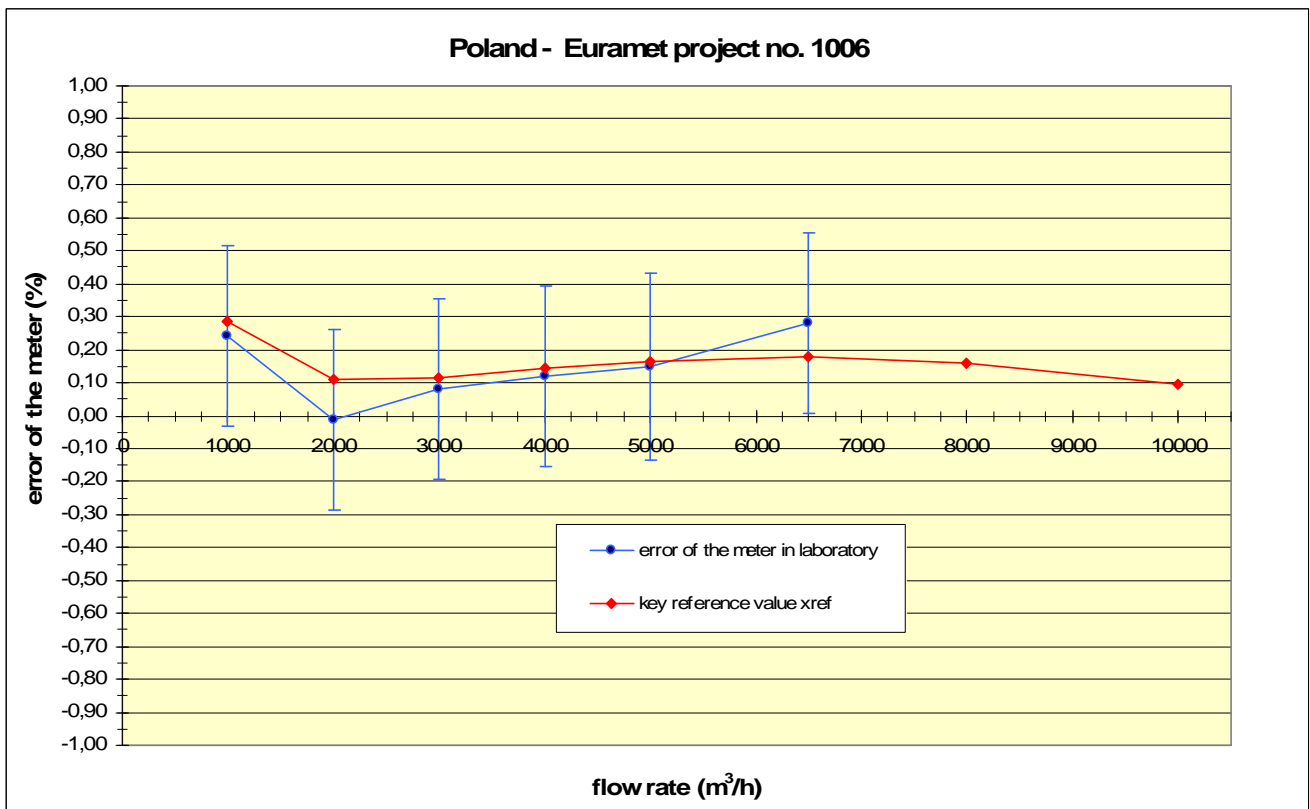
### 7.1.3. Netherlands

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	consistency check	di	Ei	result
$m^3/h$	%	%	%	%				
10000	0.100	0.157	0.094	0.093	inside	0.01	0.04	passed
8000	0.150	0.157	0.157	0.093	inside	-0.01	0.06	passed
6500	0.170	0.157	0.179	0.088	inside	-0.01	0.07	passed
5000	0.180	0.157	0.165	0.073	inside	0.02	0.11	passed
4000	0.170	0.157	0.143	0.064	inside	0.03	0.19	passed
3000	0.170	0.157	0.117	0.064	inside	0.05	0.37	passed
2000	0.190	0.157	0.112	0.064	inside	0.08	0.54	passed
1000	0.420	0.157	0.284	0.064	inside	0.14	0.95	passed
<b>mean</b>						<b>0.04</b>	<b>0.29</b>	<b>passed</b>



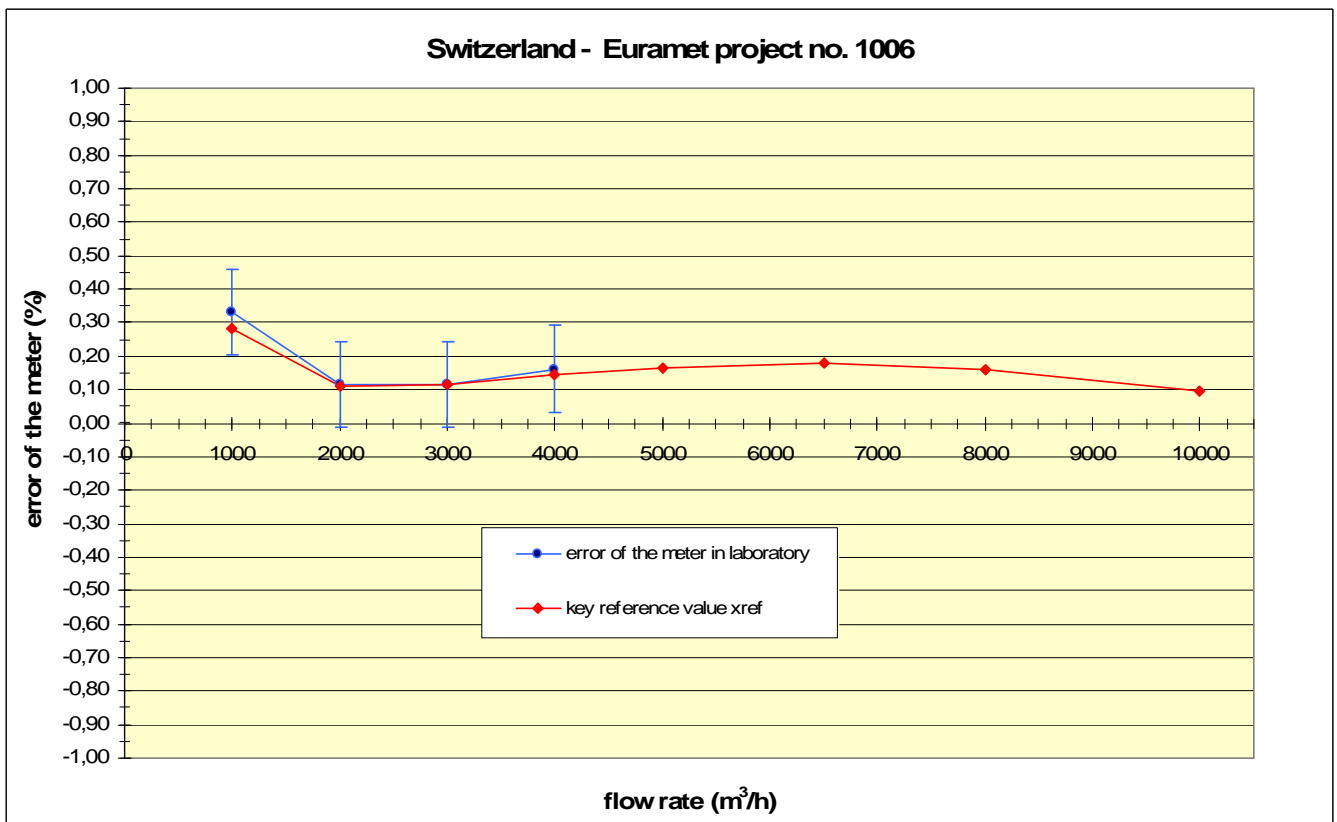
### 7.1.4. Poland

flow rate in the meter	error of the meter in laboratory	uncertainty of the error U(k=2)	key reference value $x_{ref}$	expanded uncertainty of the key reference value U( $x_{ref}$ )	consistency check	di	Ei	result
m <sup>3</sup> /h	%	%	%	%				
6500	0.280	0.274	0.179	0.088	inside	0.10	0.39	passed
5000	0.150	0.284	0.165	0.073	inside	-0.01	0.05	passed
4000	0.120	0.274	0.143	0.064	inside	-0.02	0.09	passed
3000	0.080	0.274	0.117	0.064	inside	-0.04	0.14	passed
2000	-0.010	0.274	0.112	0.064	inside	-0.12	0.46	passed
1000	0.240	0.274	0.284	0.064	inside	-0.04	0.17	passed
<b>mean</b>						<b>-0.02</b>	<b>0.22</b>	<b>passed</b>



### 7.1.5. Switzerland

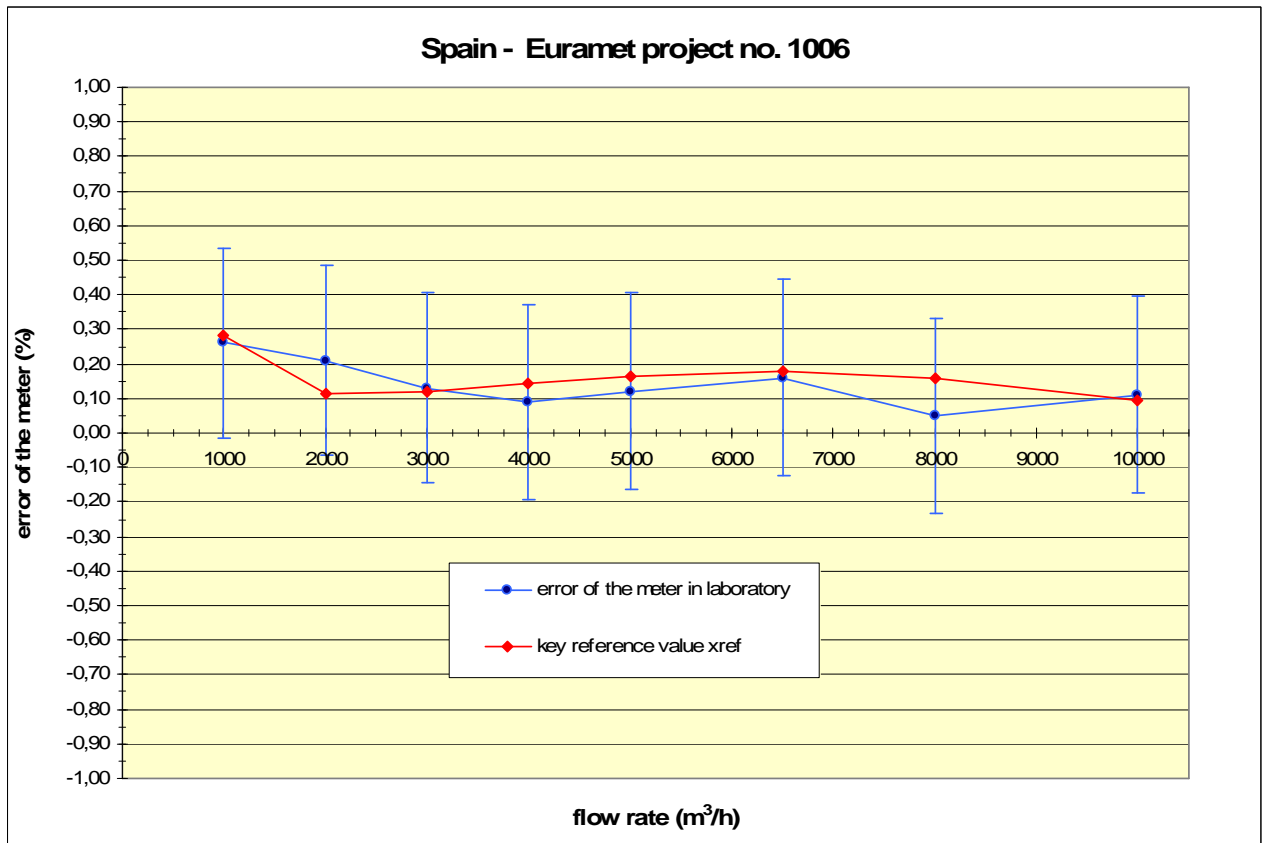
flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	consistency check	di	Ei	result
$m^3/h$	%	%	%	%				
4002.39	0.162	0.129	0.143	0.064	inside	0.02	0.17	passed
3001.59	0.116	0.129	0.117	0.064	inside	0.00	0.01	passed
2001.06	0.115	0.129	0.112	0.064	inside	0.00	0.02	passed
1000.29	0.333	0.129	0.284	0.064	inside	0.05	0.43	passed
<b>mean</b>						<b>0.02</b>	<b>0.16</b>	<b>passed</b>



## 7.2. Dependent laboratories

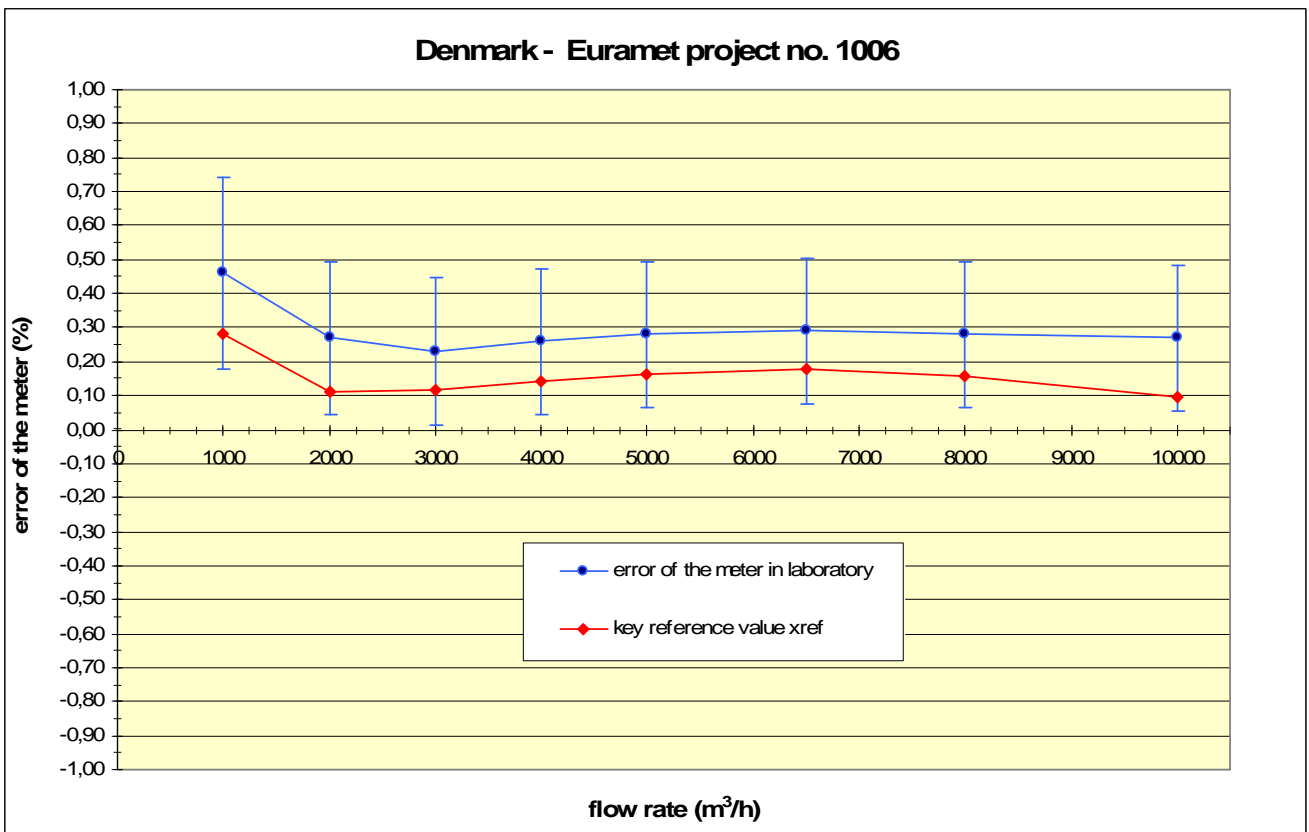
### 7.2.1. Spain

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	$d_i$	$E_i$	result
$m^3/h$	%	%	%	%			
10000	0.110	0.284	0.094	0.093	0.02	0.06	passed
8000	0.050	0.284	0.157	0.093	-0.11	0.40	passed
6500	0.160	0.284	0.179	0.088	-0.02	0.07	passed
5000	0.120	0.284	0.165	0.073	-0.04	0.16	passed
4000	0.090	0.284	0.143	0.064	-0.05	0.19	passed
3000	0.130	0.274	0.117	0.064	0.01	0.05	passed
2000	0.210	0.274	0.112	0.064	0.10	0.37	passed
1000	0.260	0.274	0.284	0.064	-0.02	0.09	passed
<b>mean</b>					<b>-0.02</b>	<b>0.17</b>	<b>passed</b>



## 7.2.2. Denmark

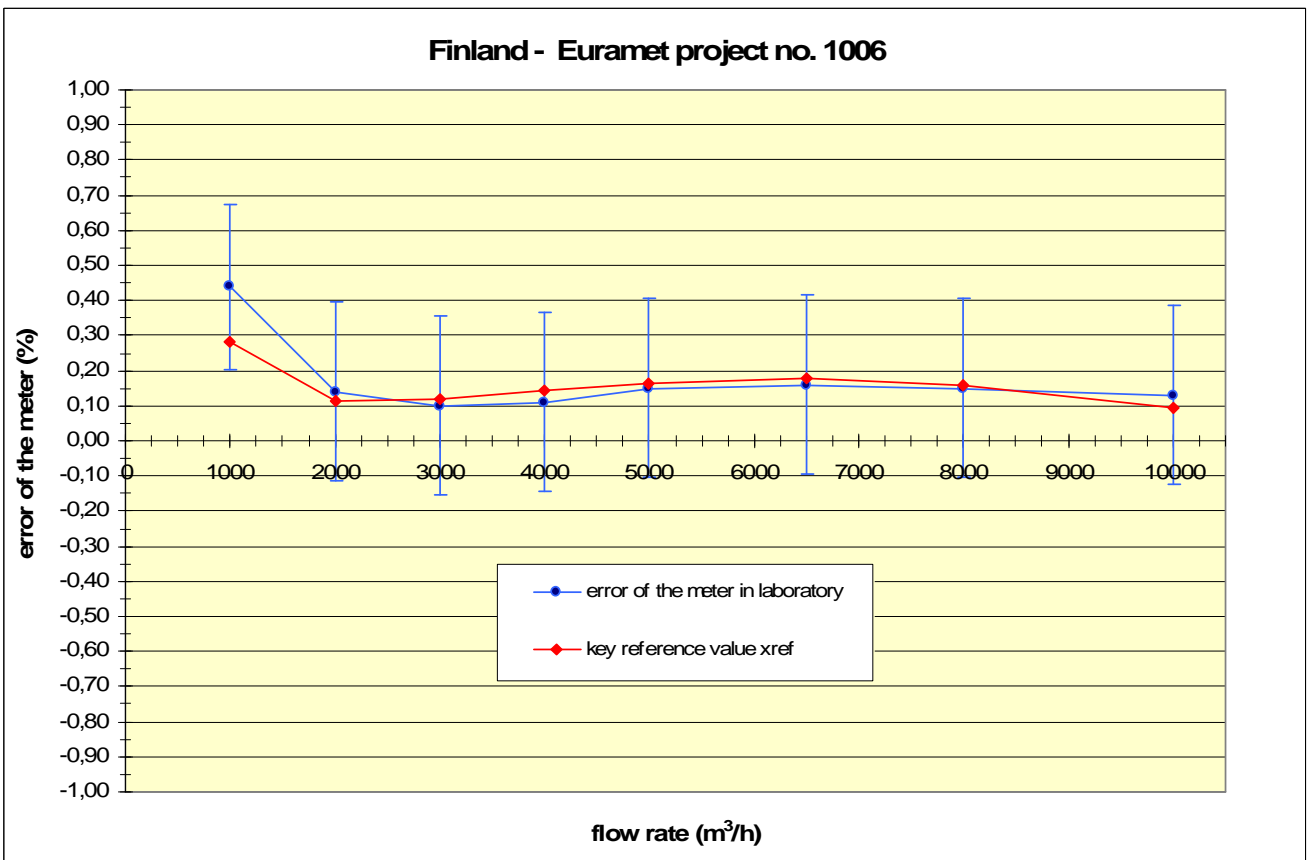
flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	$d_i$	$E_i$	result
$m^3/h$	%	%	%	%			
10000	0.270	0.215	0.094	0.093	0.18	0.91	passed
8000	0.280	0.215	0.157	0.093	0.12	0.63	passed
6500	0.290	0.215	0.179	0.088	0.11	0.56	passed
5000	0.280	0.215	0.165	0.073	0.12	0.57	passed
4000	0.260	0.215	0.143	0.064	0.12	0.57	passed
3000	0.230	0.215	0.117	0.064	0.11	0.55	passed
2000	0.270	0.225	0.112	0.064	0.16	0.73	passed
1000	0.460	0.284	0.284	0.064	0.18	0.64	passed
<b>mean</b>					<b>0.14</b>	<b>0.65</b>	<b>passed</b>





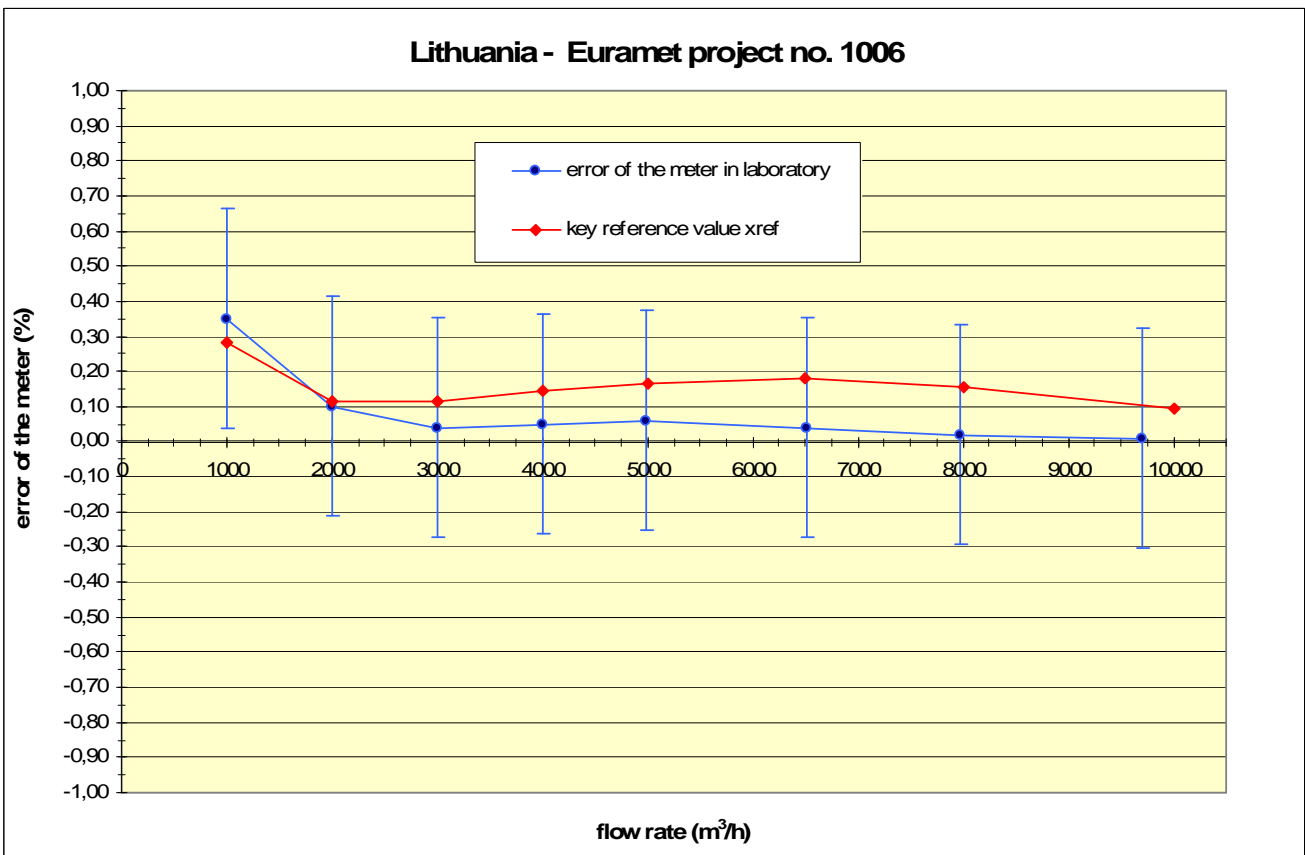
### 7.2.3. Finland

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
10000	0.130	0.254	0.094	0.093	0.04	0.15	passed
8000	0.150	0.254	0.157	0.093	-0.01	0.03	passed
6500	0.160	0.254	0.179	0.088	-0.02	0.08	passed
5000	0.150	0.254	0.165	0.073	-0.01	0.06	passed
4000	0.110	0.254	0.143	0.064	-0.03	0.13	passed
3000	0.100	0.254	0.117	0.064	-0.02	0.07	passed
2000	0.140	0.254	0.112	0.064	0.03	0.11	passed
1000	0.440	0.235	0.284	0.064	0.16	0.69	passed
<b>mean</b>					<b>0.02</b>	<b>0.17</b>	<b>passed</b>



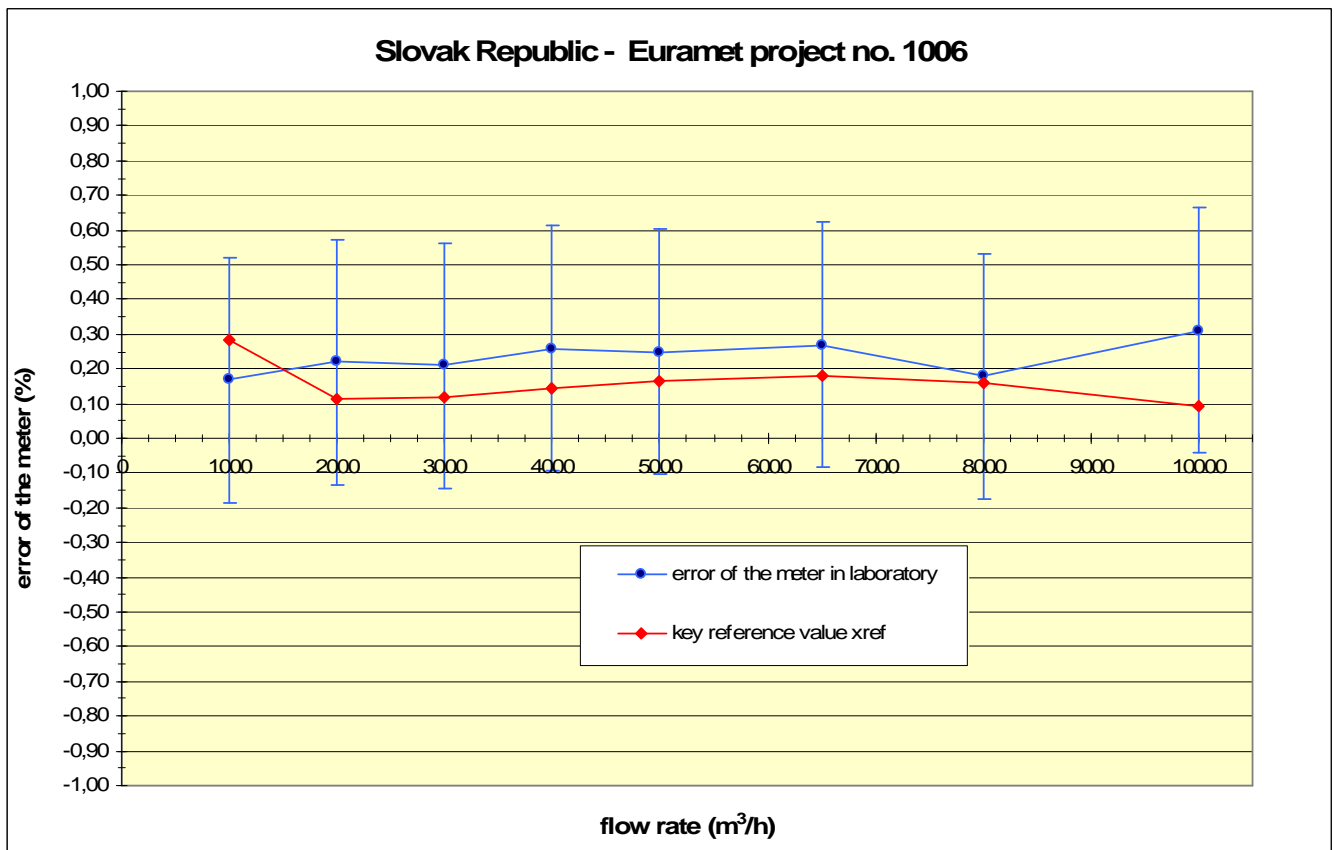
## 7.2.4. Lithuania

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
9700.00	0.010	0.313	0.094	0.093	-0.08	0.28	passed
7971.00	0.020	0.313	0.157	0.093	-0.14	0.46	passed
6511.00	0.040	0.313	0.179	0.088	-0.14	0.46	passed
4995.00	0.060	0.313	0.165	0.073	-0.10	0.34	passed
3998.00	0.050	0.313	0.143	0.064	-0.09	0.30	passed
3002.00	0.040	0.313	0.117	0.064	-0.08	0.25	passed
2004.00	0.100	0.313	0.112	0.064	-0.01	0.04	passed
1006.00	0.350	0.313	0.284	0.064	0.07	0.21	passed
<b>mean</b>					<b>-0.07</b>	<b>0.29</b>	<b>passed</b>



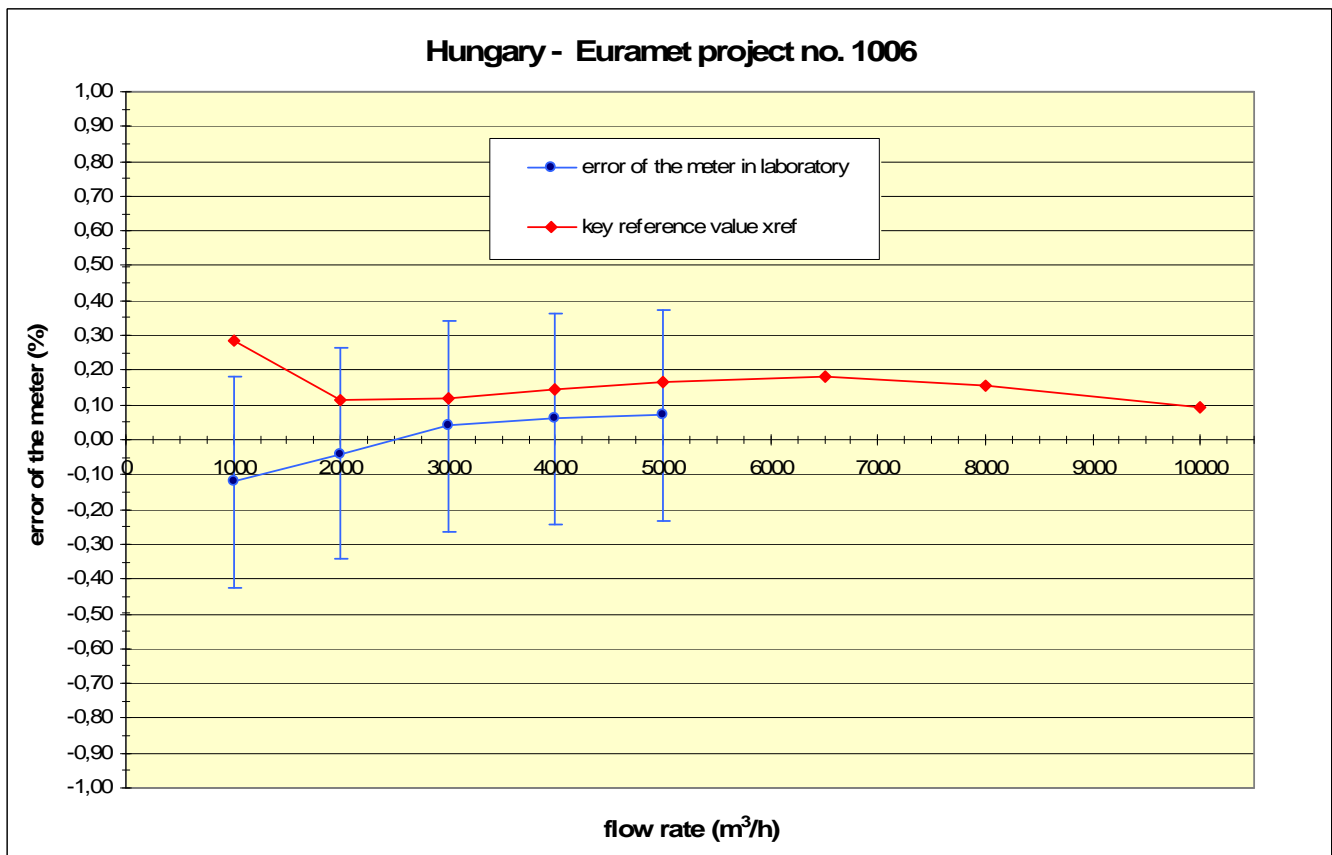
### 7.2.5. Slovak Republic

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
10000.00	0.310	0.353	0.094	0.093	0.22	0.63	passed
8000.00	0.180	0.353	0.157	0.093	0.02	0.07	passed
6500.00	0.270	0.353	0.179	0.088	0.09	0.27	passed
5000.00	0.250	0.353	0.165	0.073	0.09	0.25	passed
4000.00	0.260	0.353	0.143	0.064	0.12	0.34	passed
3000.00	0.210	0.353	0.117	0.064	0.09	0.27	passed
2000.00	0.220	0.353	0.112	0.064	0.11	0.31	passed
1000.00	0.170	0.353	0.284	0.064	-0.11	0.33	passed
<b>mean</b>					<b>0.08</b>	<b>0.31</b>	<b>passed</b>



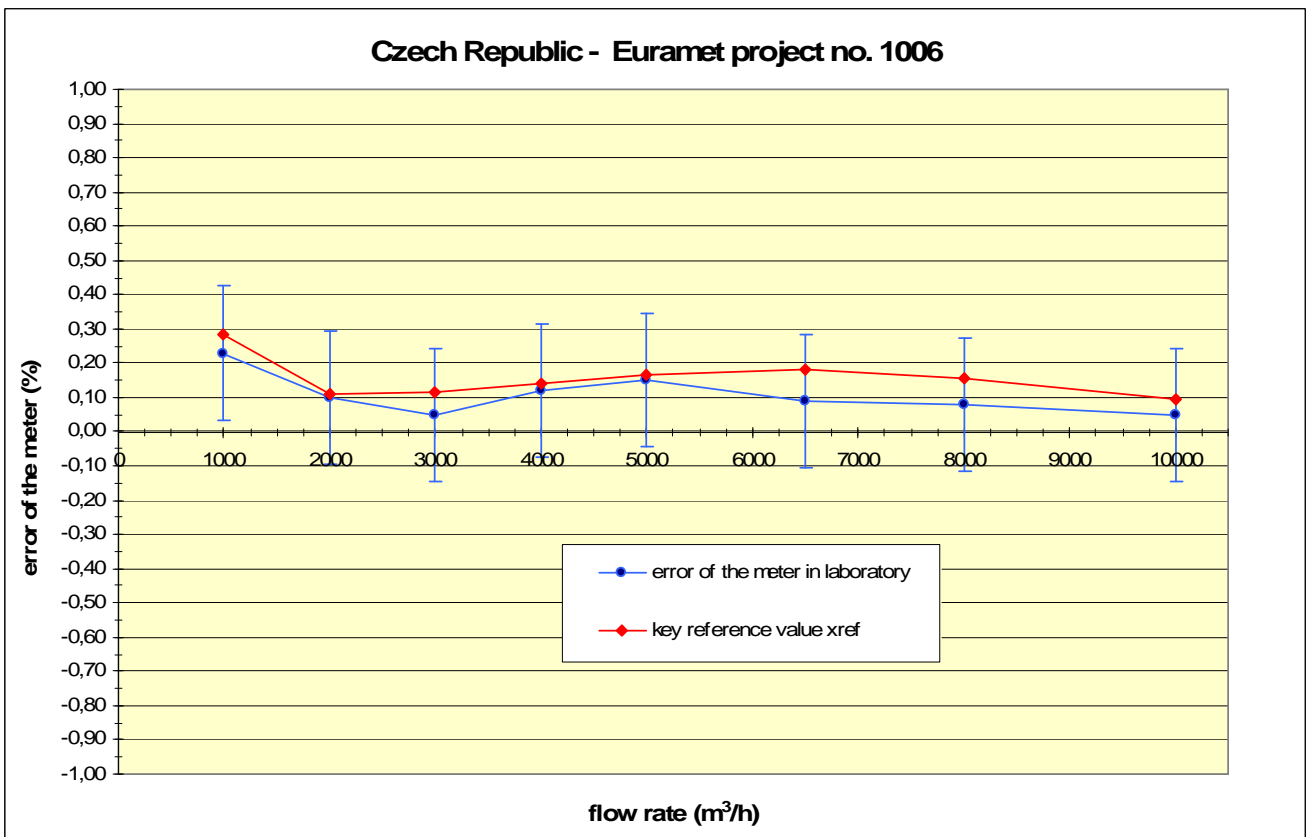
### 7.2.6. Hungary

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
5000.00	0.070	0.304	0.165	0.073	-0.09	0.32	passed
4000.00	0.060	0.304	0.143	0.064	-0.08	0.28	passed
3000.00	0.040	0.304	0.117	0.064	-0.08	0.26	passed
2000.00	-0.040	0.304	0.112	0.064	-0.15	0.51	passed
1000.00	-0.120	0.304	0.284	0.064	-0.40	1.36	failed
<b>mean</b>					<b>-0.16</b>	<b>0.55</b>	<b>passed</b>



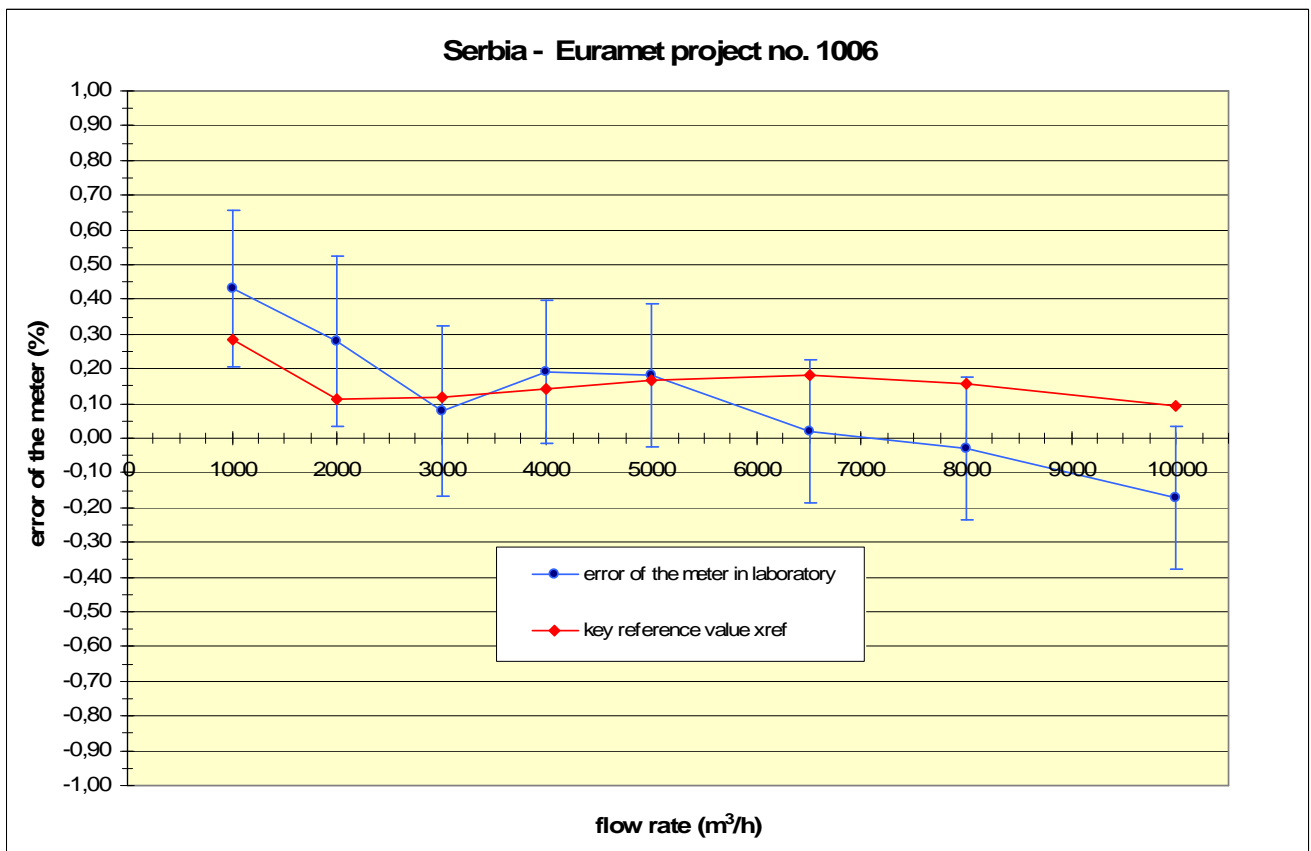
### 7.2.7. Czech Republic

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
10000	0.050	0.195	0.094	0.093	-0.04	0.26	passed
8000	0.080	0.195	0.157	0.093	-0.08	0.45	passed
6500	0.090	0.195	0.179	0.088	-0.09	0.51	passed
5000	0.150	0.195	0.165	0.073	-0.01	0.08	passed
4000	0.120	0.195	0.143	0.064	-0.02	0.13	passed
3000	0.050	0.195	0.117	0.064	-0.07	0.36	passed
2000	0.100	0.195	0.112	0.064	-0.01	0.07	passed
1000	0.230	0.195	0.284	0.064	-0.05	0.29	passed
<b>mean</b>					<b>-0.05</b>	<b>0.27</b>	<b>passed</b>



### 7.2.8. Serbia

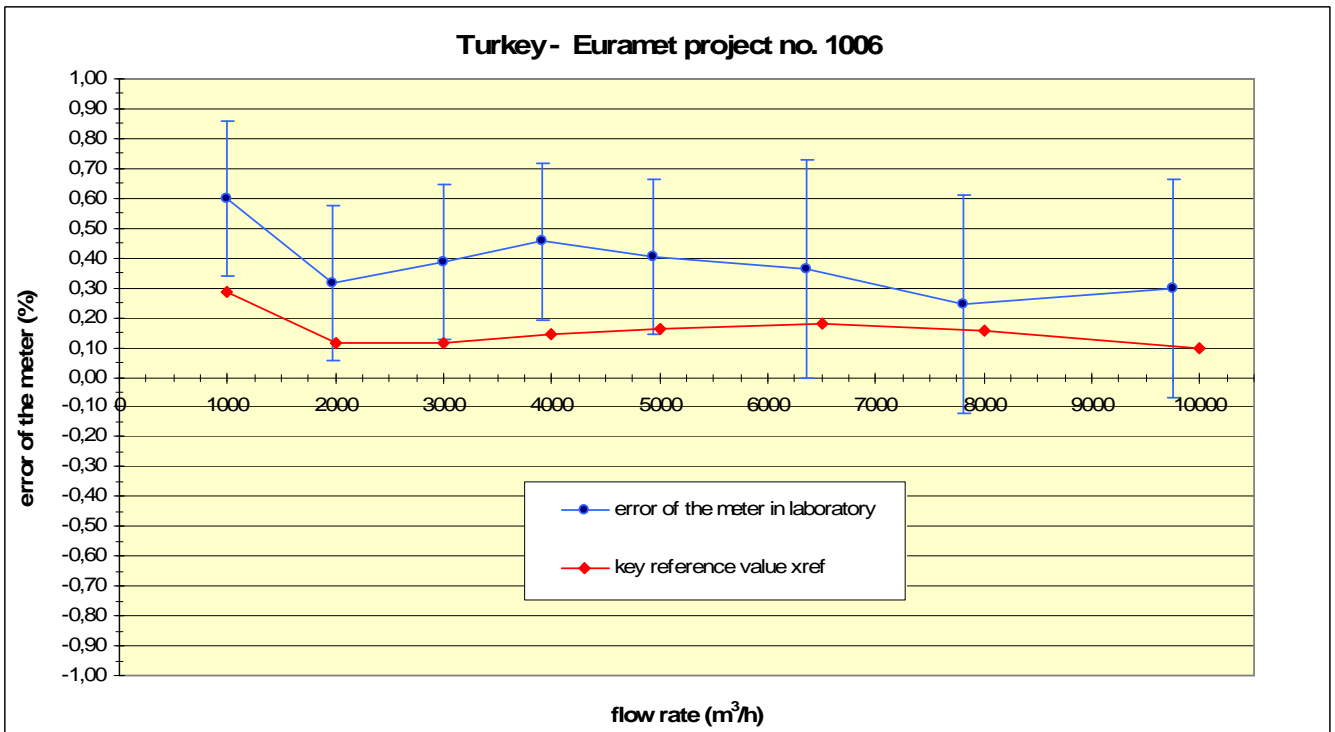
flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	di	Ei	result
m <sup>3</sup> /h	%	%	%	%			
1000	-0.170	0.205	0.094	0.093	-0.26	1.45	failed
8000	-0.030	0.205	0.157	0.093	-0.19	1.02	warning
6500	0.020	0.205	0.179	0.088	-0.16	0.86	passed
5000	0.180	0.205	0.165	0.073	0.02	0.08	passed
4000	0.190	0.205	0.143	0.064	0.05	0.24	passed
3000	0.080	0.244	0.117	0.064	-0.04	0.16	passed
2000	0.280	0.244	0.112	0.064	0.17	0.71	passed
1000	0.430	0.225	0.284	0.064	0.15	0.68	passed
<b>mean</b>					<b>-0.03</b>	<b>0.65</b>	<b>passed</b>





### 7.2.9. Turkey

flow rate in the meter	error of the meter in laboratory	uncertainty of the error $U(k=2)$	key reference value $x_{ref}$	expanded uncertainty of the key reference value $U(x_{ref})$	$d_i$	$E_i$	result
$m^3/h$	%	%	%	%			
9753.87	0.300	0.366	0.094	0.093	0.21	0.58	passed
7804.09	0.243	0.366	0.157	0.093	0.09	0.24	passed
6363.02	0.362	0.366	0.179	0.088	0.18	0.52	passed
4934.16	0.405	0.262	0.165	0.073	0.24	0.95	passed
3908.57	0.455	0.262	0.143	0.064	0.31	1.23	failed
2996.69	0.387	0.262	0.117	0.064	0.27	1.06	warning
1976.15	0.315	0.262	0.112	0.064	0.20	0.80	passed
987.63	0.599	0.262	0.284	0.064	0.31	1.24	failed
<b>mean</b>					<b>0.23</b>	<b>0.83</b>	<b>passed</b>



## 8. Degree of equivalence between laboratories

As it was mentioned above in this project there were 5 independent laboratories (---):

Germany, France, Netherlands, Poland, Switzerland

In this project there were 5 laboratories traceable to Netherlands (VSL):

Denmark, Finland, Hungary, Serbia, Turkey

In this project there were 4 laboratories traceable to Germany (PTB):

Spain, Lithuania, Slovak Republic, Czech Republic

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

The pair of values is red if  $E_{ij}$  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  $E_{ij}$  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  $E_{ij}$  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.

Flow rate	Finland-Hungary (VSL/VSL)		Finland-Germany (VSL/---)		Finland-Netherlands (VSL/VSL)		Finland-Denmark (VSL/VSL)		Finland-Poland (VSL/---)		Finland-Lithuania (VSL/PTB)		Finland-Slovak Rep. (VSL/PTB)	
	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$D_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$
10000			-0,01	0,05	0,03	0,14	-0,14	0,26			0,12	0,30	-0,18	0,41
8000			-0,05	0,17	0,00	0,00	-0,13	0,26			0,13	0,32	-0,03	0,07
6500			-0,04	0,12	-0,01	0,05	-0,13	0,26	-0,12	0,32	0,12	0,30	-0,11	0,25
5000	0,08	0,24	-0,02	0,06	-0,03	0,14	-0,13	0,26	0,00	0,00	0,09	0,22	-0,10	0,23
4000	0,05	0,15	-0,03	0,09	-0,06	0,29	-0,15	0,26	-0,01	0,03	0,06	0,15	-0,15	0,34
3000	0,06	0,18	-0,01	0,04	-0,07	0,33	-0,13	0,26	0,02	0,05	0,06	0,15	-0,11	0,25
2000	0,18	0,54	0,02	0,09	-0,05	0,24	-0,13	0,26	0,15	0,40	0,04	0,10	-0,08	0,18
1000	0,56	1,75	0,19	0,74	0,02	0,11	-0,02	0,30	0,20	0,55	0,09	0,23	0,27	0,64
<b>Mean</b>	<b>0,19</b>	<b>0,57</b>	<b>0,01</b>	<b>0,17</b>	<b>-0,02</b>	<b>0,16</b>	<b>-0,12</b>	<b>0,26</b>	<b>0,04</b>	<b>0,23</b>	<b>0,09</b>	<b>0,22</b>	<b>-0,06</b>	<b>0,30</b>

Flow rate	Finland-Czech Rep. (VSL/PTB)		Finland-Switzerland (VSL/---)		Finland-Turkey (VSL/VSL)		Finland-France (VSL/---)		Finland-Spain (VSL/PTB)		Hungary-Germany (VSL/---)		Hungary-Netherlands (VSL/---)	
	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$	$d_{ij}$	$E_{ij}$
10000	0,08	0,25			-0,17	0,43	0,26	0,71	0,02	0,06				
8000	0,07	0,22			-0,09	0,24	0,13	0,36	0,10	0,32				
6500	0,07	0,22			-0,20	0,52	0,11	0,29	0,00	0,00				
5000	0,00	0,00			-0,25	0,86	0,01	0,04	0,03	0,09	-0,10	0,30	-0,11	0,41
4000	-0,01	0,03	-0,05	0,18	-0,34	1,16	0,03	0,08	0,02	0,06	-0,08	0,24	-0,11	0,41
3000	0,05	0,16	-0,02	0,06	-0,29	0,97	0,04	0,11	-0,03	0,10	-0,07	0,22	-0,13	0,49
2000	0,04	0,12	0,03	0,09	-0,18	0,59	0,17	0,47	-0,07	0,23	-0,16	0,49	-0,23	0,86
1000	0,21	0,69	0,11	0,40	-0,16	0,57	0,43	1,24	0,18	0,62	-0,37	1,18	-0,54	2,02
<b>Mean</b>	<b>0,06</b>	<b>0,21</b>	<b>0,02</b>	<b>0,18</b>	<b>-0,21</b>	<b>0,67</b>	<b>0,15</b>	<b>0,41</b>	<b>0,03</b>	<b>0,18</b>	<b>-0,15</b>	<b>0,49</b>	<b>-0,22</b>	<b>0,84</b>

Flow rate	Hungary-Denmark (VSL/VSL)		Hungary-Poland (VSL/---)		Hungary-Lithuania (VSL/PTB)		Hungary-Slovak Rep. (VSL/PTB)		Hungary-Czech Rep. (VSL/PTB)		Hungary-Switzerland (VSL/---)		Hungary-Turkey (VSL/VSL)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>Dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000														
8000														
6500														
5000	-0,21	0,69	-0,08	0,19	0,01	0,02	-0,18	0,39	-0,08	0,22				
4000	-0,20	0,65	-0,06	0,15	0,01	0,02	-0,20	0,43	-0,06	0,17	-0,10	0,31	-0,39	1,16
3000	-0,19	0,62	-0,04	0,10	0,00	0,00	-0,17	0,37	-0,01	0,03	-0,08	0,23	-0,35	1,02
2000	-0,31	0,99	-0,03	0,07	-0,14	0,32	-0,26	0,56	-0,14	0,39	-0,15	0,47	-0,36	1,04
1000	-0,58	1,62	-0,36	0,88	-0,47	1,08	-0,29	0,62	-0,35	0,97	-0,45	1,37	-0,72	2,11
<b>Mean</b>	<b>-0,30</b>	<b>0,92</b>	<b>-0,11</b>	<b>0,28</b>	<b>-0,12</b>	<b>0,29</b>	<b>-0,22</b>	<b>0,47</b>	<b>-0,13</b>	<b>0,35</b>	<b>-0,20</b>	<b>0,60</b>	<b>-0,43</b>	<b>1,26</b>

Flow rate	Hungary-France (VSL/---)		Hungary-Spain (VSL/ PTB)		Germany-Netherlands (---/---)		Germany-Denmark (---/VSL)		Germany-Poland (---/---)		Germany-Lithuania (---/PTB)		Germany-Slovak Rep. (---/PTB)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000					0,04	0,22	-0,13	0,50			0,13	0,46	-0,17	0,50
8000					0,05	0,23	-0,08	0,33			0,18	0,60	0,02	0,05
6500					0,03	0,12	-0,10	0,38	-0,09	0,28	0,16	0,53	-0,08	0,22
5000	-0,07	0,17	-0,05	0,12	-0,02	0,08	-0,12	0,49	0,02	0,05	0,11	0,34	-0,09	0,25
4000	-0,02	0,05	-0,03	0,07	-0,04	0,19	-0,13	0,53	0,02	0,05	0,09	0,28	-0,13	0,36
3000	-0,02	0,06	-0,09	0,22	-0,06	0,33	-0,12	0,51	0,03	0,10	0,07	0,23	-0,10	0,29
2000	-0,01	0,03	-0,25	0,61	-0,07	0,40	-0,15	0,63	0,13	0,44	0,02	0,06	-0,10	0,30
1000	-0,13	0,34	-0,38	0,93	-0,17	0,92	-0,21	0,69	0,01	0,04	-0,10	0,32	0,08	0,24
<b>Mean</b>	<b>-0,05</b>	<b>0,13</b>	<b>-0,16</b>	<b>0,39</b>	<b>-0,03</b>	<b>0,31</b>	<b>-0,13</b>	<b>0,51</b>	<b>0,02</b>	<b>0,16</b>	<b>0,08</b>	<b>0,35</b>	<b>-0,07</b>	<b>0,27</b>

Flow rate	Germany-Czech Rep. (---/PTB)		Germany-Switzerland (---/---)		Germany-Turkey (---/VSL)		Germany-France (---/---)		Germany-Spain (---/PTB)		Netherlands-Denmark (---/VSL)		Netherlands-Poland (---/---)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	0,09	0,58			-0,16	0,40	0,27	0,93	0,03	0,13	-0,17	1,06		
8000	0,12	0,73			-0,05	0,12	0,18	0,62	0,15	0,56	-0,13	0,81		
6500	0,11	0,65			-0,17	0,43	0,14	0,49	0,04	0,13	-0,12	0,75	0,11	0,35
5000	0,02	0,08			-0,24	0,86	0,03	0,10	0,05	0,16	-0,10	0,62	0,03	0,09
4000	0,02	0,08	-0,03	0,17	-0,32	1,15	0,05	0,20	0,05	0,16	-0,09	0,56	0,05	0,16
3000	0,06	0,33	-0,01	0,04	-0,28	1,00	0,05	0,18	-0,02	0,08	-0,06	0,37	0,09	0,29
2000	0,02	0,09	0,00	0,02	-0,20	0,71	0,15	0,54	-0,09	0,35	-0,08	0,46	0,20	0,63
1000	0,02	0,12	-0,08	0,50	-0,35	1,25	0,24	0,89	-0,01	0,03	-0,04	0,16	0,18	0,57
<b>Mean</b>	<b>0,06</b>	<b>0,33</b>	<b>-0,03</b>	<b>0,18</b>	<b>-0,22</b>	<b>0,74</b>	<b>0,14</b>	<b>0,49</b>	<b>0,02</b>	<b>0,20</b>	<b>-0,10</b>	<b>0,60</b>	<b>0,11</b>	<b>0,35</b>

Flow rate	Netherlands-Lithuania (---/PTB)		Netherlands-Slovak Rep. (---/PTB)		Netherlands-Czech Rep. (---/PTB)		Netherlands-Switzerland (---/---)		Netherlands-Turkey (---/VSL)		Netherlands-France (---/---)		Netherlands-Spain (---/PTB)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	0,09	0,26	-0,21	0,54	0,05	0,20			-0,20	0,59	0,23	0,75	-0,01	0,03
8000	0,13	0,37	-0,03	0,08	0,07	0,28			-0,09	0,28	0,13	0,43	0,10	0,31
6500	0,13	0,37	-0,10	0,26	0,08	0,32			-0,19	0,57	0,12	0,39	0,01	0,03
5000	0,12	0,34	-0,07	0,18	0,03	0,12			-0,22	1,02	0,04	0,15	0,06	0,19
4000	0,12	0,34	-0,09	0,23	0,05	0,20	0,01	0,04	-0,28	1,30	0,09	0,30	0,08	0,25
3000	0,13	0,37	-0,04	0,10	0,12	0,48	0,05	0,27	-0,22	0,99	0,11	0,36	0,04	0,13
2000	0,09	0,26	-0,03	0,08	0,09	0,36	0,08	0,37	-0,13	0,57	0,22	0,73	-0,02	0,06
1000	0,07	0,20	0,25	0,65	0,19	0,76	0,09	0,43	-0,18	0,81	0,41	1,36	0,16	0,51
<b>Mean</b>	<b>0,11</b>	<b>0,31</b>	<b>-0,04</b>	<b>0,27</b>	<b>0,09</b>	<b>0,34</b>	<b>0,06</b>	<b>0,28</b>	<b>-0,19</b>	<b>0,77</b>	<b>0,17</b>	<b>0,56</b>	<b>0,05</b>	<b>0,19</b>

Flow rate	Denmark-Poland (VSL/---)		Denmark-Lithuania (VSL/PTB)		Denmark-Slovak Rep. (VSL/PTB)		Denmark-Czech Rep. (VSL/PTB)		Denmark-Switzerland (VSL/---)		Denmark-Turkey (VSL/VSL)		Denmark-France (VSL/---)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>dij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>Eij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000			0,26	0,68	-0,04	0,10	0,22	0,76			-0,03	0,08	0,40	1,18
8000			0,26	0,68	0,10	0,24	0,20	0,69			0,04	0,10	0,26	0,78
6500	0,01	0,03	0,25	0,66	0,02	0,05	0,20	0,69			-0,07	0,20	0,24	0,71
5000	0,13	0,37	0,22	0,58	0,03	0,07	0,13	0,45			-0,12	0,47	0,14	0,43
4000	0,14	0,40	0,21	0,55	0,00	0,00	0,14	0,48	0,10	0,39	-0,19	0,74	0,18	0,54
3000	0,15	0,43	0,19	0,50	0,02	0,05	0,18	0,62	0,11	0,46	-0,16	0,59	0,17	0,50
2000	0,28	0,79	0,17	0,44	0,05	0,12	0,17	0,57	0,16	0,60	-0,05	0,17	0,30	0,88
1000	0,22	0,56	0,11	0,26	0,29	0,64	0,23	0,67	0,13	0,41	-0,14	0,43	0,45	1,17
<b>Mean</b>	<b>0,16</b>	<b>0,43</b>	<b>0,21</b>	<b>0,54</b>	<b>0,06</b>	<b>0,16</b>	<b>0,18</b>	<b>0,62</b>	<b>0,12</b>	<b>0,46</b>	<b>-0,09</b>	<b>0,35</b>	<b>0,27</b>	<b>0,77</b>

Flow rate	Denmark-Spain (VSL/ PTB)		Poland-Lithuania (---/PTB)		Poland-Slovak Rep. (---/PTB)		Poland-Czech Rep. (---/PTB)		Poland-Switzerland (---/---)		Poland-Turkey (---/VSL)		Poland-France (---/---)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>Dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>Dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	0,16	0,45												
8000	0,23	0,65												
6500	0,13	0,37	0,24	0,58	0,01	0,02	0,19	0,56			-0,08	0,18	0,23	0,60
5000	0,16	0,45	0,09	0,21	-0,10	0,22	0,00	0,00			-0,25	0,66	0,01	0,04
4000	0,17	0,48	0,07	0,17	-0,14	0,31	0,00	0,00	-0,04	0,14	-0,33	0,88	0,04	0,11
3000	0,10	0,29	0,04	0,10	-0,13	0,29	0,03	0,09	-0,04	0,12	-0,31	0,81	0,02	0,05
2000	0,06	0,17	-0,11	0,26	-0,23	0,51	-0,11	0,33	-0,12	0,41	-0,33	0,86	0,02	0,05
1000	0,20	0,51	-0,11	0,26	0,07	0,16	0,01	0,03	-0,09	0,31	-0,36	0,95	0,23	0,61
<b>Mean</b>	<b>0,15</b>	<b>0,42</b>	<b>0,04</b>	<b>0,26</b>	<b>-0,09</b>	<b>0,25</b>	<b>0,02</b>	<b>0,17</b>	<b>-0,07</b>	<b>0,24</b>	<b>-0,28</b>	<b>0,72</b>	<b>0,09</b>	<b>0,24</b>

Flow rate	Poland-Spain (---/PTB)		Lithuania-Slovak Rep. (PTB/PTB)		Lithuania-Czech Rep. (PTB/PTB)		Lithuania-Switzerland (PTB/---)		Lithuania-Turkey (PTB/VSL)		Lithuania-France (PTB/---)		Lithuania-Spain (PTB/ PTB)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000			-0,30	0,68	-0,04	0,12			-0,29	0,60	0,14	0,34	-0,10	0,26
8000			-0,16	0,36	-0,06	0,18			-0,22	0,46	0,00	0,00	-0,03	0,08
6500	0,12	0,30	-0,23	0,52	-0,05	0,15			-0,32	0,67	-0,01	0,04	-0,12	0,31
5000	0,03	0,07	-0,19	0,41	-0,09	0,26			-0,34	0,84	-0,08	0,19	-0,06	0,15
4000	0,03	0,08	-0,21	0,46	-0,07	0,20	-0,11	0,33	-0,40	0,99	-0,03	0,08	-0,04	0,10
3000	-0,05	0,13	-0,17	0,37	-0,01	0,03	-0,08	0,22	-0,35	0,85	-0,02	0,06	-0,09	0,22
2000	-0,22	0,57	-0,12	0,26	0,00	0,00	-0,01	0,04	-0,22	0,53	0,13	0,32	-0,11	0,27
1000	-0,02	0,05	0,18	0,39	0,12	0,34	0,02	0,05	-0,25	0,61	0,34	0,84	0,09	0,22
<b>Mean</b>	<b>-0,02</b>	<b>0,20</b>	<b>-0,15</b>	<b>0,43</b>	<b>-0,03</b>	<b>0,16</b>	<b>-0,05</b>	<b>0,16</b>	<b>-0,30</b>	<b>0,69</b>	<b>0,06</b>	<b>0,23</b>	<b>-0,06</b>	<b>0,20</b>

Flow rate	Slovak Rep.-Czech Rep. (PTB/PTB)		Slovak Rep.-Switzerland (PTB/---)		Slovak Rep.-Turkey (PTB/VSL)		Slovak Rep.-France (PTB/---)		Slovak Rep.-Spain (PTB/ PTB)		Czech Rep.-Switzerland (PTB/---)		Czech Rep.-Turkey (PTB/VSL)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	0,26	0,71			0,01	0,02	0,44	1,00	0,20	0,48			-0,25	0,60
8000	0,10	0,27			-0,06	0,12	0,16	0,36	0,13	0,31			-0,16	0,39
6500	0,18	0,49			-0,09	0,18	0,22	0,50	0,11	0,26			-0,27	0,66
5000	0,10	0,26			-0,15	0,35	0,11	0,26	0,13	0,30			-0,25	0,78
4000	0,14	0,36	0,10	0,26	-0,19	0,44	0,18	0,41	0,17	0,39	-0,04	0,18	-0,33	1,02
3000	0,16	0,41	0,09	0,25	-0,18	0,40	0,15	0,34	0,08	0,19	-0,07	0,28	-0,34	1,03
2000	0,12	0,31	0,11	0,28	-0,10	0,22	0,25	0,57	0,01	0,02	-0,01	0,06	-0,22	0,66
1000	-0,06	0,15	-0,16	0,43	-0,43	0,98	0,16	0,36	-0,09	0,21	-0,10	0,44	-0,37	1,13
<b>Mean</b>	<b>0,13</b>	<b>0,37</b>	<b>0,03</b>	<b>0,31</b>	<b>-0,15</b>	<b>0,34</b>	<b>0,21</b>	<b>0,48</b>	<b>0,09</b>	<b>0,27</b>	<b>-0,06</b>	<b>0,24</b>	<b>-0,27</b>	<b>0,78</b>

Flow rate	Czech Rep.-France (PTB/---)		Czech Rep.-Spain (PTB/ PTB)		Switzerland-Turkey (---/VSL)		Switzerland-France (---/---)		Switzerland-Spain (---/PTB)		Turkey-France (VSL/---)		Turkey-Spain (VSL/ PTB)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	0,18	0,55	-0,06	0,20							0,43	0,95	0,19	0,41
8000	0,06	0,18	0,03	0,10							0,22	0,50	0,19	0,42
6500	0,04	0,11	-0,07	0,23							0,31	0,69	0,20	0,44
5000	0,01	0,04	0,03	0,09							0,27	0,73	0,28	0,74
4000	0,04	0,12	0,03	0,09	-0,29	1,00	0,08	0,29	0,07	0,23	0,37	1,02	0,36	0,94
3000	-0,01	0,04	-0,08	0,25	-0,27	0,93	0,05	0,19	-0,01	0,05	0,32	0,89	0,26	0,68
2000	0,13	0,40	-0,11	0,35	-0,20	0,69	0,14	0,50	-0,10	0,32	0,34	0,94	0,11	0,28
1000	0,22	0,68	-0,03	0,09	-0,27	0,91	0,32	1,12	0,07	0,24	0,59	1,61	0,34	0,89
<b>Mean</b>	<b>0,08</b>	<b>0,27</b>	<b>-0,03</b>	<b>0,18</b>	<b>-0,26</b>	<b>0,88</b>	<b>0,15</b>	<b>0,53</b>	<b>0,01</b>	<b>0,21</b>	<b>0,36</b>	<b>0,92</b>	<b>0,24</b>	<b>0,60</b>

Flow rate	France-Spain (---/PTB)		Finland-Serbia (VSL/VSL)		Hungary-Serbia (VSL/VSL)		Germany-Serbia (---/VSL)		Netherland-Serbia (---/VSL)		Denmark-Serbia (VSL/VSL)		Poland-Serbia (---/VSL)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>
10000	-0,24	0,62	0,30	1,21			0,31	1,30	0,27	1,83	0,44	2,11		
8000	-0,03	0,07	0,18	0,72			0,23	0,94	0,18	1,22	0,31	1,49		
6500	-0,11	0,28	0,14	0,56			0,18	0,72	0,15	1,02	0,27	1,30	0,26	0,76
5000	0,02	0,04	-0,03	0,12	-0,11	0,37	-0,02	0,07	0,00	0,00	0,10	0,48	-0,03	0,09
4000	-0,01	0,02	-0,08	0,32	-0,13	0,44	-0,06	0,24	-0,02	0,14	0,07	0,34	-0,07	0,20
3000	-0,07	0,18	0,02	0,07	-0,04	0,12	0,03	0,11	0,09	0,45	0,15	0,61	0,00	0,00
2000	-0,24	0,64	-0,14	0,50	-0,32	0,98	-0,16	0,62	-0,09	0,45	-0,01	0,04	-0,29	0,79
1000	-0,25	0,66	0,01	0,04	-0,55	1,76	-0,18	0,73	-0,01	0,06	0,03	0,10	-0,19	0,54
<b>Mean</b>	<b>-0,12</b>	<b>0,32</b>	<b>0,05</b>	<b>0,44</b>	<b>-0,23</b>	<b>0,73</b>	<b>0,04</b>	<b>0,59</b>	<b>0,07</b>	<b>0,65</b>	<b>0,17</b>	<b>0,81</b>	<b>-0,05</b>	<b>0,40</b>

Flow rate	Lithuania-Serbia (PTB/VSL)		Slovak Rep.-Serbia (PTB/VSL)		Czech Rep.-Serbia (PTB/VSL)		Switzerland-Serbia (---/VSL)		Turkey-Serbia (VSL/VSL)		France-Serbia (---/VSL)		Spain-Serbia (PTB/VSL)	
	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>dij</i>	<i>Eij</i>	<i>Dij</i>	<i>Eij</i>
10000	0,18	0,48	0,48	1,18	0,22	0,78			0,47	1,30	0,04	0,12	0,28	0,80
8000	0,05	0,13	0,21	0,51	0,11	0,39			0,27	0,75	0,05	0,16	0,08	0,23
6500	0,02	0,05	0,25	0,61	0,07	0,25			0,34	0,95	0,03	0,10	0,14	0,40
5000	-0,12	0,32	0,07	0,17	-0,03	0,11			0,22	0,88	-0,04	0,13	-0,06	0,17
4000	-0,14	0,37	0,07	0,17	-0,07	0,25	-0,03	0,12	0,26	1,03	-0,11	0,34	-0,10	0,29
3000	-0,04	0,10	0,13	0,30	-0,03	0,10	0,04	0,13	0,31	1,06	-0,02	0,05	0,05	0,14
2000	-0,18	0,45	-0,06	0,14	-0,18	0,58	-0,17	0,60	0,04	0,12	-0,31	0,88	-0,07	0,19
1000	-0,08	0,21	-0,26	0,62	-0,20	0,67	-0,10	0,38	0,17	0,62	-0,42	1,23	-0,17	0,48
<b>Mean</b>	<b>-0,04</b>	<b>0,27</b>	<b>0,11</b>	<b>0,46</b>	<b>-0,01</b>	<b>0,39</b>	<b>-0,06</b>	<b>0,31</b>	<b>0,26</b>	<b>0,84</b>	<b>-0,10</b>	<b>0,38</b>	<b>0,02</b>	<b>0,34</b>

## 9. Summary and conclusion

The summary of results is mentioned down in the *tables 5, 6 and 7*. The independent laboratories are light green. The laboratories with traceability to Germany (PTB) are light yellow. The laboratories with traceability to 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 5*.



**Table 5 – 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	France	Finland	Hungary	Denmark	Lithuania	Slovak Rep.	Czech Rep.	Turkey	Spain	Serbia	
10000	passed	passed			passed	passed		passed	passed	passed	passed	passed	passed	failed	
8000	passed	passed			passed	passed		passed	passed	passed	passed	passed	passed	warning	
6500	passed	passed	passed		passed	passed		passed	passed	passed	passed	passed	passed	passed	
5000	passed	passed	passed		passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	
4000	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	failed	passed	
3000	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	warning	passed	passed	
2000	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	passed	
1000	passed	passed	passed	passed	warning	passed	failed	passed	passed	passed	passed	passed	failed	passed	
<b>Mean</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	<b>passed</b>	

The complete evaluation of each laboratory concerning the mean coefficients  $E_i$  (equation [13]) and  $E_{ij}$  (equation [14]) is summarised in the table 6. In the **diagonal** there are the mean coefficients  $E_i$  which express the equivalence with the key comparison reference value. In other cells there are coefficients  $E_{ij}$  which express the equivalence of one laboratory with another laboratory.

**Table 6 -The complete evaluation of each laboratory concerning  
the mean coefficients  $E_i$  and  $E_{ij}$**

	Switzerland	Finland	Spain	Poland	Germany	Czech Rep.	Netherland	Lithuania	Slovak Rep.	France	Hungary	Denmark	Serbia	Turkey
<b>Switzerland</b>	<b>0,157</b>	0,182	0,208	0,243	0,181	0,240	0,278	0,162	0,306	0,525	0,595	0,464	0,305	0,883
<b>Finland</b>	0,182	<b>0,166</b>	0,185	0,226	0,169	0,211	0,162	0,221	0,298	0,412	0,572	0,263	0,443	0,666
<b>Spain</b>	0,208	0,185	<b>0,174</b>	0,201	0,201	0,177	0,187	0,202	0,269	0,316	0,391	0,419	0,336	0,599
<b>Poland</b>	0,243	0,226	0,201	<b>0,215</b>	0,162	0,168	0,348	0,264	0,253	0,242	0,278	0,429	0,396	0,723
<b>Germany</b>	0,181	0,169	0,201	0,162	<b>0,241</b>	0,334	0,312	0,351	0,275	0,495	0,485	0,510	0,592	0,740
<b>Czech Rep.</b>	0,240	0,211	0,177	0,168	0,334	<b>0,268</b>	0,339	0,160	0,372	0,266	0,355	0,615	0,388	0,784
<b>Netherland</b>	0,278	0,162	0,187	0,348	0,312	0,339	<b>0,291</b>	0,314	0,265	0,559	0,836	0,599	0,646	0,766
<b>Lithuania</b>	0,162	0,221	0,202	0,264	0,351	0,160	0,314	<b>0,294</b>	0,433	0,232	0,289	0,545	0,265	0,694
<b>Slovak Rep.</b>	0,306	0,298	0,269	0,253	0,275	0,372	0,265	0,433	<b>0,307</b>	0,476	0,473	0,158	0,464	0,339
<b>France</b>	0,525	0,412	0,316	0,242	0,495	0,266	0,559	0,232	0,476	<b>0,526</b>	0,128	0,774	0,376	0,917
<b>Hungary</b>	0,595	0,572	0,391	0,278	0,485	0,355	0,836	0,289	0,473	0,128	<b>0,547</b>	0,916	0,733	<b>1,264</b>
<b>Denmark</b>	0,464	0,263	0,419	0,429	0,510	0,615	0,599	0,545	0,158	0,774	0,916	<b>0,645</b>	0,808	0,347
<b>Serbia</b>	0,305	0,443	0,336	0,396	0,592	0,388	0,646	0,265	0,464	0,376	0,733	0,808	<b>0,648</b>	0,839
<b>Turkey</b>	0,883	0,666	0,599	0,723	0,740	0,784	0,766	0,694	0,339	0,917	<b>1,264</b>	0,347	0,839	<b>0,827</b>

The complete evaluation of each laboratory concerning the mean coefficients  $d_i$  (equation [11]) and  $d_{ij}$  (equation [12]) is summarised in the *table 7*. In the **diagonal** there are the mean coefficients  $d_i$  which express the equivalence with the key comparison reference value. In other cells there are coefficients  $d_{ij}$  which express the equivalence of one laboratory with another laboratory.

*Table 7 -The complete evaluation of each laboratory concerning the mean coefficients  $d_i$  and  $d_{ij}$*

	Hungary	France	Lithuania	Czech Rep.	Serbia	Poland	Spain	Germany	Finland	Switzerland	Netherland	Slovakia	Denmark	Turkey
Hungary	<b>-0,162</b>	-0,051	-0,118	-0,128	-0,230	-0,114	-0,160	-0,154	-0,186	-0,196	-0,224	-0,220	-0,298	<b>-0,430</b>
France	0,051	<b>-0,131</b>	-0,058	-0,083	-0,096	-0,090	-0,115	-0,138	-0,146	-0,150	-0,168	-0,208	-0,266	-0,357
Lithuania	0,118	0,058	<b>-0,073</b>	-0,025	-0,039	-0,037	-0,058	-0,081	-0,089	-0,046	-0,110	-0,150	-0,209	-0,299
Czech Rep.	0,128	0,083	0,025	<b>-0,048</b>	-0,014	-0,020	-0,033	-0,056	-0,064	-0,056	-0,085	-0,125	-0,184	-0,274
Serbia	0,230	0,096	0,039	0,014	<b>-0,034</b>	0,053	-0,019	-0,042	-0,050	0,064	-0,071	-0,111	-0,170	-0,261
Poland	0,114	0,090	0,037	0,020	-0,053	<b>-0,023</b>	-0,018	-0,019	-0,040	-0,074	-0,110	-0,087	-0,155	-0,277
Spain	0,160	0,115	0,058	0,033	0,019	0,018	<b>-0,015</b>	-0,023	-0,031	-0,009	-0,053	-0,093	-0,151	-0,242
Germany	0,154	0,138	0,081	0,056	0,042	0,019	0,023	<b>0,008</b>	-0,008	-0,027	-0,029	-0,069	-0,128	-0,219
Finland	0,186	0,146	0,089	0,064	0,050	0,040	0,031	0,008	<b>0,016</b>	0,016	-0,021	-0,061	-0,120	-0,211
Switzerland	0,196	0,150	0,046	0,056	-0,064	0,074	0,009	0,027	-0,016	<b>0,017</b>	-0,056	-0,034	-0,124	-0,258
Netherland	0,224	0,168	0,110	0,085	0,071	0,110	0,053	0,029	0,021	0,056	<b>0,037</b>	-0,040	-0,099	-0,189
Slovakia	0,220	0,208	0,150	0,125	0,111	0,087	0,093	0,069	0,061	0,034	0,040	<b>0,077</b>	-0,059	-0,149
Denmark	0,298	0,266	0,209	0,184	0,170	0,155	0,151	0,128	0,120	0,124	0,099	0,059	<b>0,136</b>	-0,091
Turkey	<b>0,430</b>	0,357	0,299	0,274	0,261	0,277	0,242	0,219	0,211	0,258	0,189	0,149	0,091	<b>0,227</b>

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

