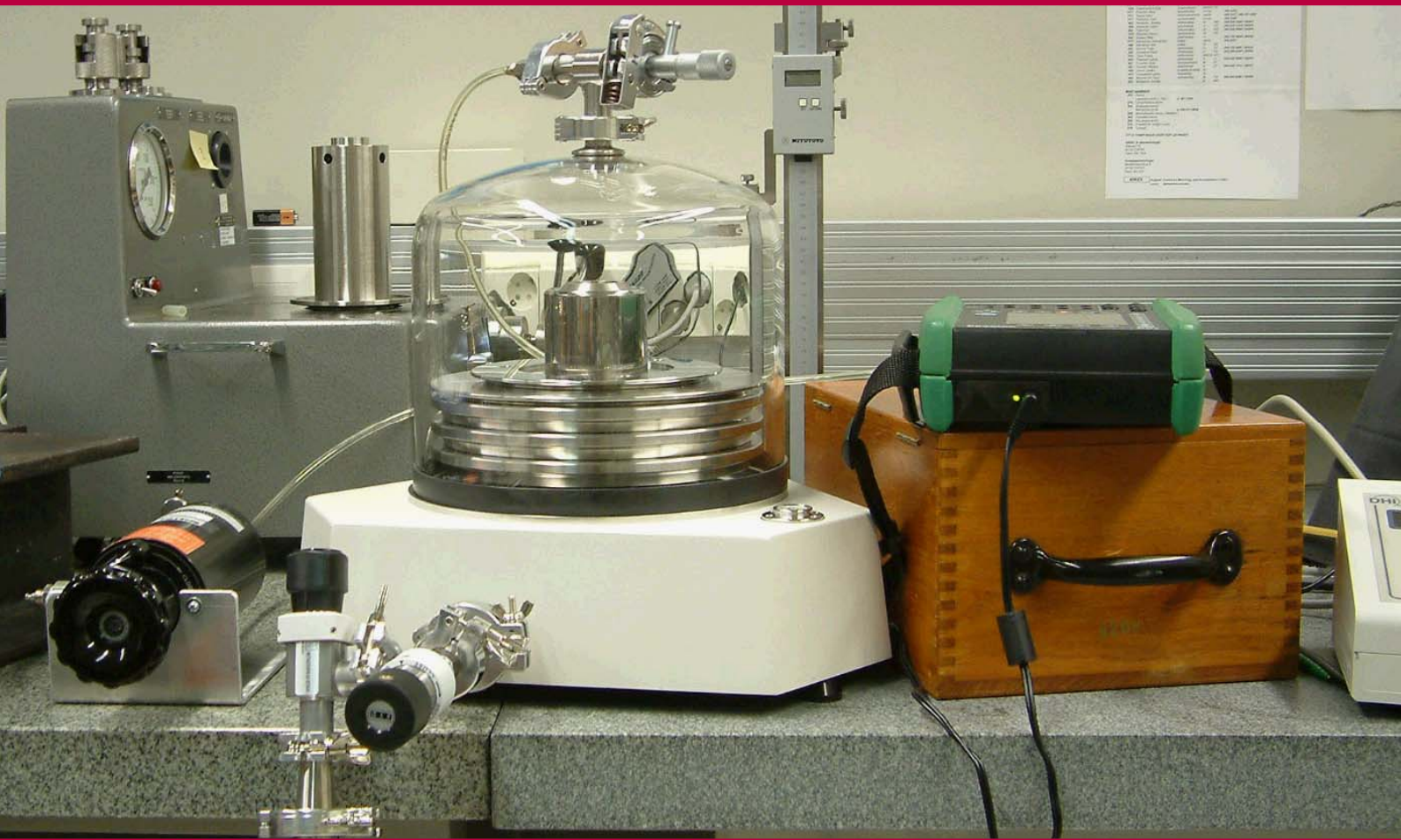


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Intercomparison in Gauge Pressure Range from -95 kPa to +100 kPa

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Abstract

An intercomparison in the gauge pressure range from -95 kPa to +100 kPa was arranged in 2005 in Finland by the Centre for Metrology and Accreditation (MIKES). Five pressure calibration laboratories participated in the comparison but only three made measurements on both negative and positive gauge pressures.

The transfer standard was a Beamex MC5 multifunction calibrator equipped with an internal pressure measurement module INT1C for the gauge pressure range -105 kPa to + 104 kPa.

The results from all the five laboratories were in a good agreement with the results of MIKES. Only one result at nominal pressure -95 kPa was slightly out of the uncertainty limits.

Tiivistelmä

Mittatekniikan keskus (MIKES) järjesti vuonna 2005 vertailumittauksen ylipainealueella -95 kPa ... +100 kPa. Vertailumittaukseen osallistui viisi kalibrointilaboratoriota Suomesta. Näistä kolme teki mittaukset sekä negatiivisella että positiivisella ylipaineella.

Kiertävä vertailulaite oli Beamex MC5 monitoimikalibraattori varustettuna sisäisellä paineenmittausmodulilla INTC1 ylipainealueelle -105 kPa ... +104 kPa.

Kaikkien laboratorioiden tulokset olivat mittauserävarmuuksien puitteissa samoja kuin MIKESin tulokset paitsi yhden laboratorion yksi tulos nimellispaineella -95 kPa.

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1 Introduction

Centre for Metrology and Accreditation (MIKES) has arranged several inter-comparisons for pressure calibration laboratories during the last 15 years. As negative gauge pressures were not covered by any of these comparisons this range was selected as one of the ranges for the pressure inter-comparison P17 in 2005.

For negative gauge pressure calibrations the use of a traditional pressure balance with the bell jar around the piston and the weights is more complicated than that for the positive ones. The float position control may sometimes be difficult, and the gas buoyancy must be corrected for each measured pressure separately.

2 Participants

The following laboratories participated in the comparison:

Finnair Oy, Test Equipment Calibration, Vantaa
Finnish Air Force, Air Materiel Command, Tampere
Inspecta Oy, Measuring Technology, Helsinki
Oy Beamex Ab, Calibration Laboratory, Pietarsaari
VTT Technical Research Centre of Finland, Industrial Systems (from 1st of January 2006 on: VTT Technical Research Centre of Finland, Medical Device Technology), Tampere

Three of the laboratories were accredited on the whole pressure range of the inter-comparison.

3 Reference Laboratory

The reference standard used at MIKES for the range of the inter-comparison is a DH Instruments PG7607 pressure balance, which can be used in the absolute mode as well. The nominal value for the effective area of the piston is 1960 mm².

The best measurement capability for the PG7607 of MIKES is estimated as 0,1 Pa + $2,2 \cdot 10^{-5} \cdot p$, where p is pressure. The effective areas of the pressure balances in MIKES are traceable to Laboratoire National d'Essais (LNE), Paris.

4 Transfer Standard

The transfer standard was a Beamex MC5 Multifunction Calibrator s/n 23512308 equipped with an internal pressure measurement module INT1C s/n 26532. The resolution of the display for this module is 0,001 kPa when *kPa* is selected as the unit for pressure.

The authors are grateful to Oy Beamex Ab for providing the transfer standard.

5 Measurement Instructions

The participants were asked to keep the transfer standard switched on overnight before starting the calibration. For measurements in the positive gauge pressure range they were asked to pre-pressurise the transfer standard three times to +100 kPa and then set the zero. For negative pressures the given pre-pressurisation before zeroing was three times to -100 kPa.

The participants were advised to calibrate the transfer standard using three up-and-down cycles and to calculate the results separately for increasing and decreasing pressures to eliminate hysteresis effects. The following nominal pressures were specified:

Positive:

0 kPa, +20 kPa, +40 kPa, +60 kPa, +80 kPa and +100 kPa

Negative:

0 kPa, -20 kPa, -40 kPa, -60 kPa, -80 kPa and -95 kPa.

Finally, the participants were asked to send their results as calibration certificates to MIKES within two weeks after the measurements.

6 Calculation of the Reference Values

The transfer standard was calibrated four times at the reference laboratory MIKES. The first calibration was made in early September and the last in the middle of November 2005. The results were presented in certificates M-05P089, M-05P108, M-05P117 and M-05P118.

Figure 1 shows the result points from all the four calibrations at MIKES. Obviously there is some time dependent drift in the results.

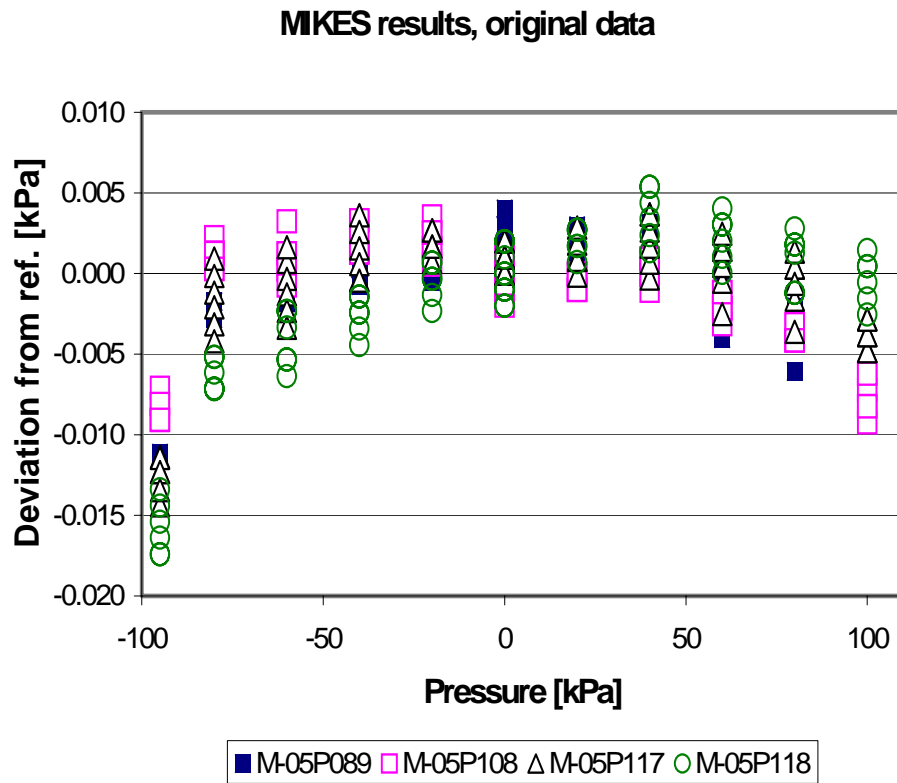


Figure 1. Results of the four calibrations at MIKES. Original data

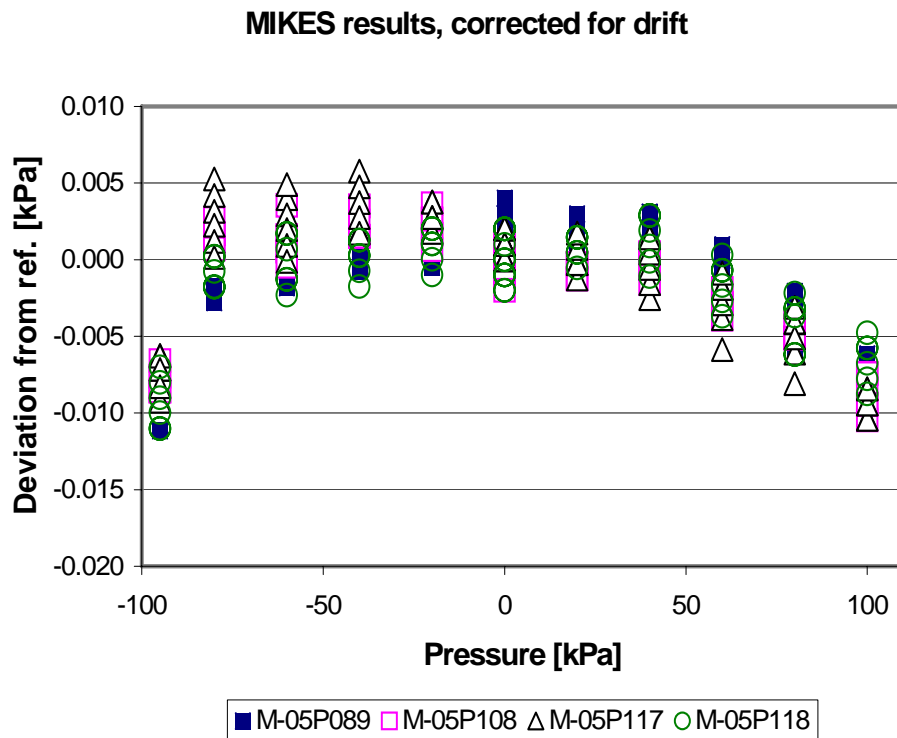


Figure 2. Results of the four calibrations at MIKES. Corrected for drift.

Figure 2 illustrates the results modified to the date of the first calibration at MIKES using linear drift correction $-3,27 \cdot 10^{-5}$ / month. The observed drift rate is approximately 0,04% per year, corresponding 40 Pa per year at 100 kPa.

The reference values for each participant were calculated from the averages of the drift corrected MIKES results shown in Figure 2, the time elapsed from the first MIKES calibration, and the drift rate.

The uncertainties of the reference values were calculated according to document EA-4/02 and a coverage factor $k = 2$. The major uncertainty components taken into account were the following:

- uncertainty in setting the zero of the transfer standard
- resolution of the transfer standard
- standard deviation of the averages of the drift corrected MIKES results
- uncertainty of the measurement standard.

The reference values corrected to the date of the first calibration at MIKES and their uncertainties are shown in Table 1.

Table 1. The averages of the MIKES calibration results corrected to the date of the first calibration

Nominal pressure kPa	Direction of pressure change	Average corrected to first MIKES calibration date kPa	Uncertainty kPa
0	increasing	+0,0008	0,0028
+20	increasing	-0,0004	0,0030
+40	increasing	-0,0006	0,0034
+60	increasing	-0,0030	0,0040
+80	increasing	-0,0052	0,0044
+100	increasing	-0,0085	0,0048
+100	decreasing	-0,0076	0,0049
+80	decreasing	-0,0036	0,0043
+60	decreasing	-0,0011	0,0038
+40	decreasing	+0,0017	0,0035
+20	decreasing	+0,0011	0,0031
0	decreasing	+0,0018	0,0028
0	decreasing	+0,0001	0,0028
-20	decreasing	+0,0026	0,0030
-40	decreasing	+0,0030	0,0038
-60	decreasing	+0,0025	0,0041
-80	decreasing	+0,0019	0,0046
-95	decreasing	-0,0079	0,0047
-95	increasing	-0,0086	0,0048
-80	increasing	-0,0001	0,0047
-60	increasing	-0,0002	0,0040
-40	increasing	+0,0008	0,0036
-20	increasing	+0,0012	0,0033
0	increasing	-0,0009	0,0030

7 Results

All of the participating laboratories could not present their results as their typical calibration certificates as the pressure range was outside their accredited scope. However, the results were given with uncertainties estimated using the document EA-4/02 and a coverage factor $k = 2$.

Following the EA inter-comparison practice all laboratories were given letter codes. Each laboratory knows only its own code.

All the five participating laboratories A to E made the measurements on positive nominal pressures but only A, C and D on negative ones.

All the results are shown in the Appendix.

The results on nominal pressures + 40 kPa, +100 kPa, -60 kPa and -95 kPa were selected as examples to illustrate the results, +40 kPa and +100 kPa in increasing direction, and -60 kPa and -95 kPa in decreasing direction (Figures 3 to 6)

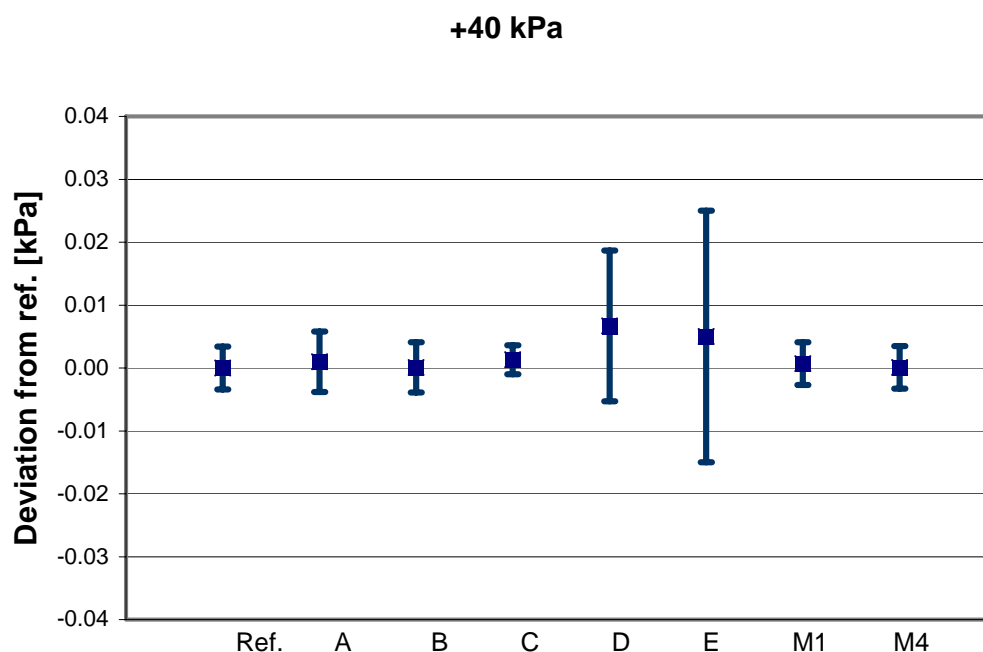


Figure 3. Results at nominal pressure +40 kPa in increasing direction.

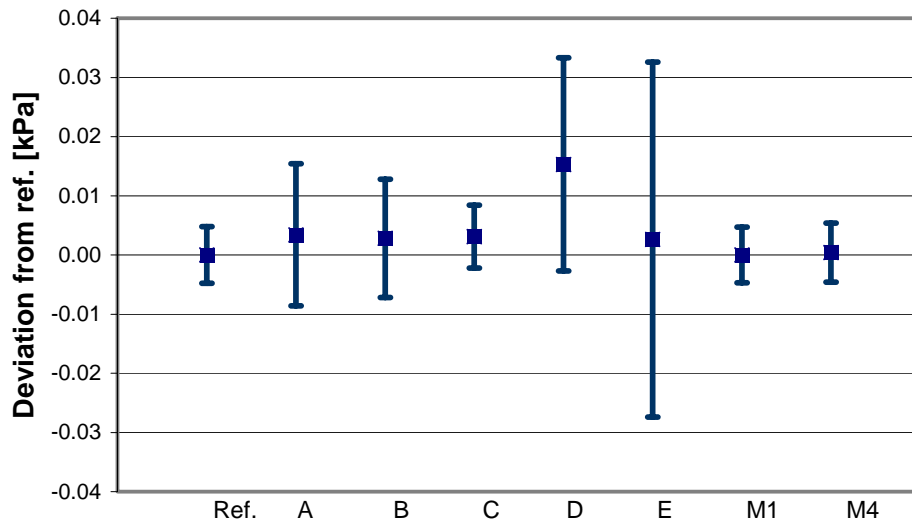
+100 kPa

Figure 4. Results at nominal pressure +100 kPa in increasing direction.

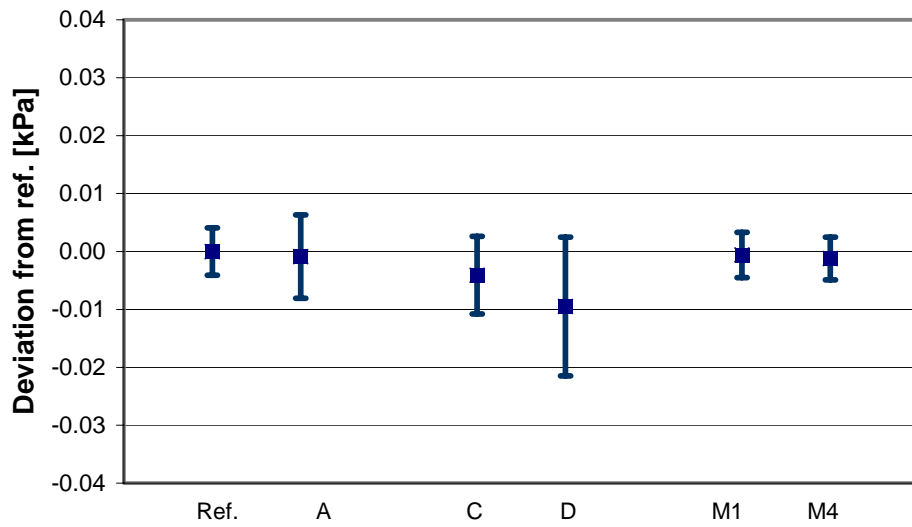
-60 kPa decreasing

Figure 5. Results at nominal pressure -60 kPa in decreasing direction.

-95 kPa

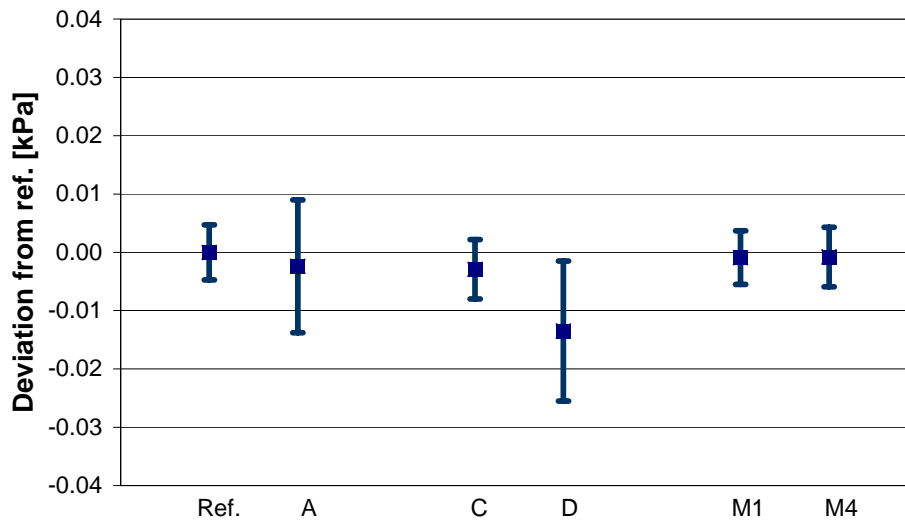


Figure 6. Results at nominal pressure -95 kPa in decreasing direction.

A tool often used in analysing results from inter-laboratory comparisons is the normalised error E_n , which takes into account both the result and its uncertainty. The normalised error E_n is calculated as

$$E_n = \frac{(p_{transfer} - p_{std})_{lab} - (p_{transfer} - p_{std})_{ref}}{\sqrt{(U_{lab}^2 + U_{ref}^2)}}$$

where

$p_{transfer}$	is pressure indicated by the transfer standard,
p_{std}	is the pressure of the laboratory standard,
U_{lab}	is the uncertainty of the laboratory result, and
U_{ref}	is the uncertainty of the reference value.

The E_n -values of all the results are also shown in the Appendix, not only for the participating laboratories but also for the four calibrations in the reference laboratory MIKES (M1 to M4). The E_n -values are also illustrated in Figure 7.

A summary of the E_n -values is in the following table

Laboratory

Laboratory	Range of E_n -values, positive pressures	Range of E_n -values, negative pressures
A	-0,33 ... +0,31	-0,53 ... +0,53
B	-0,24 ... +0,40	
C	-0,32 ... +0,44	-0,82 ... -0,41
D	-0,17 ... +0,82	-1,05 ... -0,09
E	-0,04 ... +0,52	
M1	0,00 ... +0,33	-0,20 ... +0,15
M2	-0,32 ... +0,07	-0,22 ... +0,09
M3	-0,26 ... -0,08	+0,05 ... +0,56
M4	-0,12 ... +0,09	-0,43 ... -0,11

The result in an inter-laboratory comparison is regarded as correct within the limits of uncertainty, if the absolute value of the normalised error E_n is less than 1.

In this case only one E_n -value for all the results from all the laboratories was outside the limits -1 and +1. However, the E_n -values from laboratory D are clearly dependent on pressure, suggesting the need for a closer study.

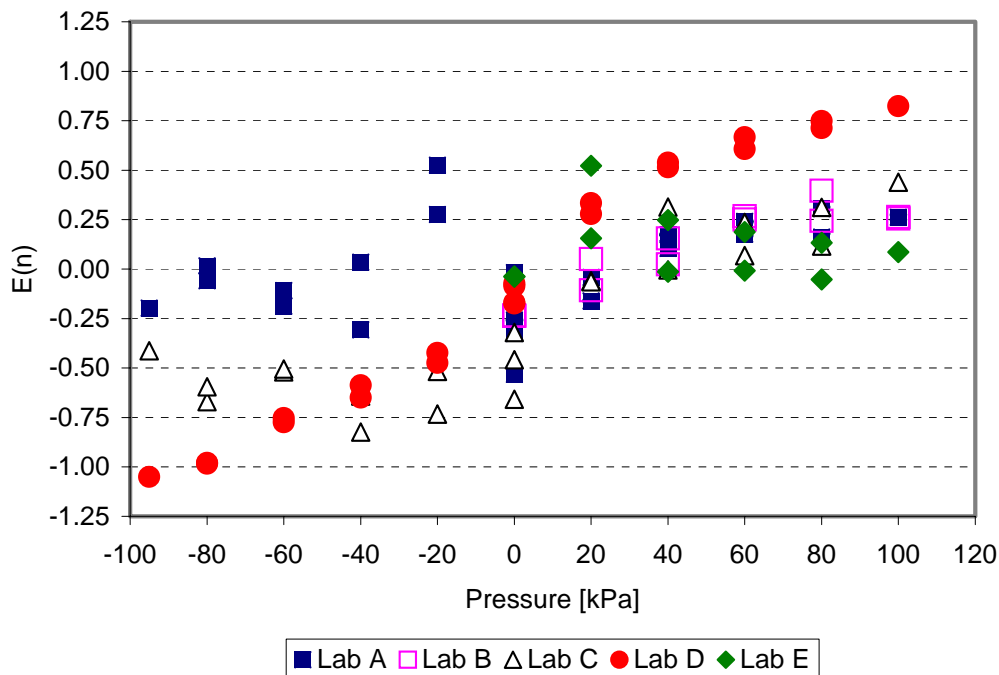


Figure 7. A summary of the E_n -values .

8 Conclusions

Five pressure calibration laboratories participated in an inter-comparison in the gauge pressure ranges from 0 kPa to +100 kPa and from -95 kPa to 0 kPa in Autumn 2005.

All the results from all the participating laboratories, except one result at nominal pressure -95 kPa, were in a good agreement with the reference values from MIKES.

The transfer standard, a Beamex MC5 Multifunction Calibrator equipped with an internal pressure measurement module INT1C, was found to be suitable for an inter-comparison at this level.

9 References

- [1] EA-4/02: Expression of the Uncertainty of Measurement in Calibration
- [2] Certificates of Calibration M-05P089, M-05P108, M-05P117 and M-05P118. Centre for Metrology and Accreditation

Appendix 1: Summary of results from each participating laboratory

Lab code A						
Nominal pressure	Result	Uncert.	Reference value	Reference uncert	Deviation from ref.	E(n)
kPa	kPa	kPa	kPa	kPa	kPa	
0	0.0000	0.0008	0.0008	0.0028	-0.0008	-0.26
20	-0.0004	0.0026	0.0002	0.0030	-0.0006	-0.16
40	0.0016	0.0048	0.0006	0.0034	0.0010	0.17
60	0.0002	0.0072	-0.0013	0.0040	0.0015	0.18
80	0.0004	0.0096	-0.0028	0.0044	0.0032	0.31
100	-0.0022	0.0120	-0.0056	0.0048	0.0034	0.26
100			-0.0047	0.0049		
80	0.0005	0.0096	-0.0012	0.0043	0.0017	0.16
60	0.0026	0.0072	0.0006	0.0038	0.0020	0.24
40	0.0035	0.0048	0.0029	0.0035	0.0006	0.11
20	0.0015	0.0024	0.0017	0.0031	-0.0002	-0.04
0	0.0008	0.0008	0.0018	0.0028	-0.0010	-0.33
0	0.0000	0.0008	0.0001	0.0028	-0.0001	-0.02
-20	0.0041	0.0024	0.0021	0.0030	0.0020	0.53
-40	0.0023	0.0048	0.0021	0.0038	0.0002	0.03
-60	0.0002	0.0072	0.0011	0.0041	-0.0009	-0.11
-80	0.0002	0.0096	0.0000	0.0046	0.0002	0.02
-95	-0.0126	0.0114	-0.0102	0.0047	-0.0024	-0.20
-95			-0.0108	0.0048		
-80	-0.0026	0.0096	-0.0020	0.0047	-0.0006	-0.06
-60	-0.0032	0.0072	-0.0017	0.0040	-0.0015	-0.19
-40	-0.0020	0.0048	-0.0002	0.0036	-0.0018	-0.31
-20	0.0019	0.0025	0.0008	0.0033	0.0011	0.28
0	-0.0025	0.0008	-0.0009	0.0030	-0.0017	-0.53

Lab code B						
Nominal pressure	Result	Uncert.	Reference value	Reference uncert	Deviation from ref.	E(n)
kPa	kPa	kPa	kPa	kPa	kPa	
0	0.0000	0.0015	0.0008	0.0028	-0.0008	-0.24
20	0.0000	0.0020	0.0004	0.0030	-0.0004	-0.11
40	0.0010	0.0040	0.0009	0.0034	0.0001	0.02
60	0.0010	0.0060	-0.0008	0.0040	0.0018	0.25
80	0.0000	0.0080	-0.0022	0.0044	0.0022	0.24
100	-0.0020	0.0100	-0.0048	0.0048	0.0028	0.26
100	-0.0010	0.0100	-0.0039	0.0049	0.0029	0.26
80	0.0030	0.0080	-0.0006	0.0043	0.0036	0.40
60	0.0030	0.0060	0.0011	0.0038	0.0019	0.27
40	0.0040	0.0040	0.0032	0.0035	0.0008	0.15
20	0.0020	0.0020	0.0018	0.0031	0.0002	0.05
0	0.0010	0.0015	0.0018	0.0028	-0.0008	-0.24

Lab code C							
Nominal pressure	Result	Uncert.	Reference value	Reference uncert	Deviation from ref.	E(n)	
kPa	kPa	kPa	kPa	kPa	kPa		
0	0.0003	0.0017	0.0008	0.0028	-0.0005	-0.14	
20	-0.0008	0.0019	-0.0006	0.0030	-0.0002	-0.06	
40	0.0002	0.0023	-0.0011	0.0034	0.0013	0.31	
60	-0.0025	0.0035	-0.0038	0.0040	0.0013	0.24	
80	-0.0042	0.0044	-0.0061	0.0044	0.0019	0.31	
100	-0.0066	0.0053	-0.0097	0.0048	0.0031	0.44	
100			-0.0088	0.0049			
80	-0.0038	0.0044	-0.0045	0.0043	0.0007	0.12	
60	-0.0015	0.0035	-0.0019	0.0038	0.0004	0.07	
40	0.0012	0.0023	0.0012	0.0035	0.0000	0.00	
20	0.0006	0.0019	0.0008	0.0031	-0.0002	-0.06	
0	0.0007	0.0017	0.0018	0.0028	-0.0011	-0.32	
0	-0.0023	0.0043	0.0001	0.0028	-0.0024	-0.46	
-20	-0.0001	0.0050	0.0029	0.0030	-0.0030	-0.52	
-40	-0.0011	0.0045	0.0038	0.0038	-0.0049	-0.82	
-60	-0.0005	0.0067	0.0036	0.0041	-0.0041	-0.52	
-80	-0.0015	0.0056	0.0034	0.0046	-0.0049	-0.67	
-95	-0.0091	0.0051	-0.0062	0.0047	-0.0029	-0.41	
-95			-0.0069	0.0048			
-80	-0.0030	0.0056	0.0014	0.0047	-0.0044	-0.60	
-60	-0.0031	0.0067	0.0008	0.0040	-0.0039	-0.50	
-40	-0.0022	0.0045	0.0015	0.0036	-0.0037	-0.64	
-20	-0.0028	0.0050	0.0016	0.0033	-0.0044	-0.73	
0	-0.0043	0.0043	-0.0009	0.0030	-0.0035	-0.66	

Lab code D							
Nominal pressure	Result	Uncert.	Reference value	Reference uncert	Deviation from ref.	E(n)	
kPa	kPa	kPa	kPa	kPa	kPa		
0	0.0000	0.0100	0.0008	0.0028	-0.0008	-0.07	
20	0.0030	0.0100	0.0001	0.0030	0.0029	0.28	
40	0.0070	0.0120	0.0003	0.0034	0.0067	0.54	
60	0.0080	0.0140	-0.0017	0.0040	0.0097	0.67	
80	0.0090	0.0160	-0.0034	0.0044	0.0124	0.75	
100	0.0090	0.0180	-0.0063	0.0048	0.0153	0.82	
100			-0.0054	0.0049			
80	0.0100	0.0160	-0.0018	0.0043	0.0118	0.71	
60	0.0090	0.0140	0.0002	0.0038	0.0088	0.61	
40	0.0090	0.0120	0.0026	0.0035	0.0064	0.51	
20	0.0050	0.0100	0.0015	0.0031	0.0035	0.33	
0	0.0000	0.0100	0.0018	0.0028	-0.0018	-0.17	
0	-0.0010	0.0120	0.0001	0.0028	-0.0011	-0.09	
-20	-0.0030	0.0120	0.0022	0.0030	-0.0052	-0.42	
-40	-0.0050	0.0120	0.0024	0.0038	-0.0074	-0.59	
-60	-0.0080	0.0120	0.0015	0.0041	-0.0095	-0.75	
-80	-0.0120	0.0120	0.0006	0.0046	-0.0126	-0.98	
-95	-0.0230	0.0120	-0.0095	0.0047	-0.0135	-1.05	
-95			-0.0101	0.0048			
-80	-0.0140	0.0120	-0.0014	0.0047	-0.0126	-0.98	
-60	-0.0110	0.0120	-0.0012	0.0040	-0.0098	-0.77	
-40	-0.0080	0.0120	0.0001	0.0036	-0.0081	-0.65	
-20	-0.0050	0.0120	0.0009	0.0033	-0.0059	-0.47	
0	-0.0030	0.0120	-0.0009	0.0030	-0.0022	-0.17	

Lab code E

Nominal pressure kPa	Result kPa	Uncert. kPa	Reference value kPa	Reference uncert. kPa	Deviation from ref. kPa	E(n)
0	0.0000	0.0200	0.0008	0.0028	-0.0008	-0.04
20	0.0110	0.0200	0.0004	0.0030	0.0106	0.52
40	0.0060	0.0200	0.0010	0.0034	0.0050	0.25
60	0.0050	0.0300	-0.0007	0.0040	0.0057	0.19
80	0.0020	0.0300	-0.0020	0.0044	0.0040	0.13
100	-0.0020	0.0300	-0.0046	0.0048	0.0026	0.09
80	-0.0020	0.0300	-0.0004	0.0043	-0.0016	-0.05
60	0.0010	0.0300	0.0012	0.0038	-0.0002	-0.01
40	0.0030	0.0200	0.0033	0.0035	-0.0003	-0.01
20	0.0050	0.0200	0.0019	0.0031	0.0031	0.16
0	0.0010	0.0200	0.0018	0.0028	-0.0008	-0.04

Lab code M1 = MIKES M-05P089

Nominal pressure kPa	Result kPa	Uncert. kPa	Reference value kPa	Reference uncert. kPa	Deviation from ref. kPa	E(n)
0	0.0017	0.0029	0.0008	0.0028	0.0010	0.24
20	0.0003	0.0031	-0.0004	0.0030	0.0007	0.15
40	0.0001	0.0034	-0.0006	0.0034	0.0007	0.15
60	-0.0024	0.0041	-0.0030	0.0040	0.0006	0.11
80	-0.0047	0.0044	-0.0052	0.0044	0.0005	0.08
100	-0.0085	0.0047	-0.0085	0.0048	0.0000	0.00
100	-0.0065	0.0047	-0.0076	0.0049	0.0011	0.17
80	-0.0024	0.0042	-0.0036	0.0043	0.0012	0.19
60	0.0000	0.0039	-0.0011	0.0038	0.0011	0.21
40	0.0028	0.0033	0.0017	0.0035	0.0011	0.23
20	0.0023	0.0028	0.0011	0.0031	0.0012	0.29
0	0.0030	0.0026	0.0018	0.0028	0.0013	0.33
0	-0.0007	0.0024	0.0001	0.0028	-0.0008	-0.20
-20	0.0022	0.0031	0.0026	0.0030	-0.0004	-0.08
-40	0.0030	0.0030	0.0030	0.0038	0.0000	-0.01
-60	0.0019	0.0039	0.0025	0.0041	-0.0006	-0.11
-80	0.0016	0.0042	0.0019	0.0046	-0.0003	-0.05
-95	-0.0088	0.0460	-0.0079	0.0047	-0.0009	-0.02
-95	-0.0081	0.0470	-0.0086	0.0048	0.0005	0.01
-80	0.0006	0.0042	-0.0001	0.0047	0.0007	0.11
-60	-0.0001	0.0037	-0.0002	0.0040	0.0001	0.02
-40	0.0013	0.0032	0.0008	0.0036	0.0005	0.11
-20	0.0019	0.0031	0.0012	0.0033	0.0007	0.15
0	-0.0013	0.0024	-0.0009	0.0030	-0.0005	-0.12

Lab code M2 = MIKES M-05P108

Nominal pressure kPa	Result kPa	Uncert. kPa	Reference value kPa	Reference uncert kPa	Deviation from ref. kPa	E(n)
0	0.0000	0.0023	0.0008	0.0028	-0.0008	-0.21
20	-0.0010	0.0028	-0.0001	0.0030	-0.0009	-0.22
40	-0.0004	0.0030	-0.0001	0.0034	-0.0003	-0.06
60	-0.0025	0.0037	-0.0023	0.0040	-0.0002	-0.04
80	-0.0038	0.0042	-0.0042	0.0044	0.0004	0.07
100	-0.0076	0.0050	-0.0073	0.0048	-0.0003	-0.04
100	-0.0076	0.0048	-0.0064	0.0049	-0.0012	-0.17
80	-0.0038	0.0042	-0.0026	0.0043	-0.0012	-0.20
60	-0.0015	0.0037	-0.0004	0.0038	-0.0011	-0.21
40	0.0009	0.0032	0.0022	0.0035	-0.0013	-0.27
20	0.0000	0.0028	0.0013	0.0031	-0.0013	-0.32
0	0.0007	0.0024	0.0018	0.0028	-0.0011	-0.28
0	0.0003	0.0024	0.0001	0.0028	0.0003	0.07
-20	0.0029	0.0028	0.0025	0.0030	0.0004	0.11
-40	0.0033	0.0032	0.0028	0.0038	0.0005	0.09
-60	0.0026	0.0039	0.0022	0.0041	0.0004	0.07
-80	0.0016	0.0042	0.0015	0.0046	0.0001	0.01
-95	-0.0081	0.0047	-0.0084	0.0047	0.0003	0.05
-95	-0.0084	0.0053	-0.0091	0.0048	0.0007	0.09
-80	-0.0007	0.0052	-0.0005	0.0047	-0.0002	-0.03
-60	-0.0004	0.0041	-0.0005	0.0040	0.0001	0.02
-40	0.0003	0.0034	0.0006	0.0036	-0.0003	-0.06
-20	0.0005	0.0030	0.0011	0.0033	-0.0006	-0.14
0	-0.0017	0.0024	-0.0009	0.0030	-0.0009	-0.22

Lab code M3 = MIKES M-05P117

Nominal pressure kPa	Result kPa	Uncert. kPa	Reference value kPa	Reference uncert kPa	Deviation from ref. kPa	E(n)
0	0.0003	0.0024	0.0008	0.0028	-0.0005	-0.12
20	0.0005	0.0028	0.0008	0.0030	-0.0003	-0.08
40	0.0007	0.0034	0.0018	0.0034	-0.0011	-0.22
60	-0.0008	0.0041	0.0005	0.0040	-0.0013	-0.23
80	-0.0016	0.0048	-0.0005	0.0044	-0.0011	-0.17
100	-0.0041	0.0048	-0.0026	0.0048	-0.0015	-0.21
100	-0.0035	0.0047	-0.0017	0.0049	-0.0018	-0.26
80	0.0004	0.0043	0.0012	0.0043	-0.0008	-0.12
60	0.0018	0.0037	0.0024	0.0038	-0.0006	-0.11
40	0.0033	0.0033	0.0041	0.0035	-0.0008	-0.16
20	0.0019	0.0030	0.0023	0.0031	-0.0004	-0.08
0	0.0013	0.0024	0.0018	0.0028	-0.0005	-0.12
0	0.0013	0.0027	0.0001	0.0028	0.0013	0.32
-20	0.0023	0.0028	0.0015	0.0030	0.0008	0.20
-40	0.0026	0.0034	0.0009	0.0038	0.0017	0.34
-60	0.0007	0.0039	-0.0007	0.0041	0.0014	0.25
-80	-0.0001	0.0043	-0.0024	0.0046	0.0023	0.37
-95	-0.0117	0.0046	-0.0131	0.0047	0.0014	0.21
-95	-0.0134	0.0047	-0.0137	0.0048	0.0003	0.05
-80	-0.0031	0.0043	-0.0044	0.0047	0.0013	0.20
-60	-0.0023	0.0039	-0.0035	0.0040	0.0012	0.21
-40	-0.0001	0.0033	-0.0014	0.0036	0.0013	0.26
-20	0.0013	0.0028	0.0001	0.0033	0.0012	0.27
0	0.0013	0.0024	-0.0009	0.0030	0.0022	0.56

Lab code M4 = MIKES M-05P118

Nominal pressure kPa	Result kPa	Uncert. kPa	Reference value kPa	Reference uncert kPa	Deviation from ref. kPa	E(n)
0	0.0010	0.0026	0.0008	0.0028	0.0003	0.07
20	0.0014	0.0028	0.0011	0.0030	0.0003	0.08
40	0.0024	0.0034	0.0023	0.0034	0.0001	0.03
60	0.0014	0.0041	0.0013	0.0040	0.0001	0.02
80	-0.0002	0.0046	0.0006	0.0044	-0.0008	-0.12
100	-0.0009	0.0050	-0.0013	0.0048	0.0004	0.06
100	0.0001	0.0050	-0.0004	0.0049	0.0005	0.08
80	0.0020	0.0043	0.0022	0.0043	-0.0002	-0.03
60	0.0030	0.0039	0.0032	0.0038	-0.0002	-0.03
40	0.0050	0.0033	0.0046	0.0035	0.0004	0.09
20	0.0027	0.0028	0.0025	0.0031	0.0002	0.04
0	0.0020	0.0023	0.0018	0.0028	0.0003	0.07
0	-0.0007	0.0024	0.0001	0.0028	-0.0008	-0.20
-20	0.0003	0.0028	0.0012	0.0030	-0.0009	-0.22
-40	-0.0018	0.0033	0.0003	0.0038	-0.0021	-0.43
-60	-0.0027	0.0037	-0.0015	0.0041	-0.0012	-0.21
-80	-0.0055	0.0040	-0.0035	0.0046	-0.0020	-0.34
-95	-0.0151	0.0051	-0.0143	0.0047	-0.0008	-0.11
-95	-0.0164	0.0047	-0.0150	0.0048	-0.0014	-0.21
-80	-0.0072	0.0042	-0.0055	0.0047	-0.0017	-0.28
-60	-0.0057	0.0037	-0.0043	0.0040	-0.0014	-0.26
-40	-0.0034	0.0034	-0.0019	0.0036	-0.0015	-0.30
-20	-0.0013	0.0030	-0.0001	0.0033	-0.0012	-0.27
0	-0.0017	0.0024	-0.0009	0.0030	-0.0009	-0.22

Recent publications

- J1/2004 J. Järvinen, M. Heinonen, A. Lassila, R. Rajala (Eds.) *Finnish National standards Laboratories Annual Report 2003*
- J2/2004 S. Semenoja, M. Rantanen, J. Leskinen and A. Pitkäkoski, *Comparison in the absolute pressure range 100 kPa to 2100 kPa between MIKES and Vaisala Oyj*
- J3/2004 V. Esala, *Pituuden vertailumittaus D6, loppuraportti*
- J4/2004 J. Halttunen, *Coriolis-mittarin vertailumittaus, syksy 2002. Interlaboratory comparison of a Coriolis flowmeter, Autumn 2002*
- J5/2004 L. Uusipaikka, *Suhteellisen kosteuden kalibrointien vertailu, loppuraportti.*
- J6/2004 K. Riski, *Mass Comparison: 2 kg, 100 g, 20 g, 2 g and 100 mg weights.*
- J7/2004 M. Rantanen, S. Semenoja, *Intercomparison in gauge pressure range from 20 Pa to 13 kPa*
- J8/2004 R. Rajala, *Yleismittarin vertailumittaus, loppuraportti*
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- J2/2005 M. Rantanen, G. Peterson, *Pressure comparisons between MIKES and Metroser: Ranges 95 kPa to 105 kPa absolute and 0,5 MPa to 1,75 MPa gauge*
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- J4/2005 T. Weckström, *Lämpötilan mittaus*
- J5/2005 M. Rantanen, S. Semenoja, *Results on the effective area of a DHI piston-cylinder unit with the nominal area of 196 mm²*
- J6/2005 T. Ehder (Toim.), *Kemian metrologian opas*
- J7/2005 M. Heinonen, J. Järvinen, A. Lassila, A. Manninen (Eds.) *Finnish National standards Laboratories Annual Report 2004*
- J8/2005 T. Weckström, *Thermometer comparison L 12 in the range from -80 °C to 400 °C*
- J9/2005 V. Esala, *Pituuden vertailumittaus D7, loppuraportti*

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