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Pressure comparisons between MIKES and Metrosert: Ranges 95 kPa to 105 kPa absolute and 0,5 MPa to 1,75 MPa gauge

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1 Introduction

The pressure laboratory of Metrosert, the leading pressure laboratory in Estonia, replaced almost all of their old reference standards with new ones in 2004 in a development project financed by the European Union. A part of the validation process for the new equipment consisted of pressure comparisons with the Centre for Metrology and Accreditation (MIKES). The measurements in Metrosert were carried out between the 27th and 30th of September 2004.

2 Comparison in the absolute pressure range 95 kPa to 105 kPa

2. 1 Transfer standard

The transfer standard in this comparison was a Vaisala PTB 200AD -barometer No. 533521 with the resolution of 0,01 hPa. The instrument is a working standard of MIKES pressure laboratory since 1994. It has been calibrated in more than 60 times, and it is found to be very stable.

2. 2 Measurements in MIKES

The best standard for barometer calibrations in MIKES is a DH Instruments PG7601 pressure balance for the range 5 kPa to 350 kPa absolute pressure. The nominal effective area of this instruments is 980 mm^2. The measurements are traceable to BNM-LNE via another pressure balance with the same nominal effective area.

The latest calibration on the Vaisala PTB 200 AD -barometer before the measurements in Metrosert was carried out on the 17th of August 2004. The results were presented in certificate M-04P071. This calibration consisted of two up-and-down cycles in the range 950 hPa to 1050 hPa in steps of 25 hPa, which is the typical procedure for barometer calibrations in MIKES. The pressurised medium was air.

The first calibration after the measurements in Metrosert was performed on the 4th of November 2004, certificate M-04P111. The results of the two MIKES calibrations are shown in the Table 1.

Table 1. MIKES results in barometric range

Nominal pressure hPa	MIKES 1st result hPa	Uncertainty of MIKES 1st. hPa	MIKES 2nd result hPa	Uncertainty of MIKES 2nd hPa	MIKES average hPa	Uncertainty of MIKES avg. hPa
950	-0,703	0,033	-0,697	0,035	-0,700	0,038
975	-0,699	0,034	-0,698	0,034	-0,699	0,037
1000	-0,692	0,034	-0,699	0,035	-0,696	0,039
1025	-0,692	0,035	-0,696	0,037	-0,694	0,039
1050	-0,680	0,036	-0,683	0,036	-0,682	0,038

2. 3 Measurements in Metrosert

The new standard of Metrosert for absolute pressure calibrations in the barometric range is a pressure balance manufactured by Pressurements, model 6100, with the nominal effective area of 202 mm^2 and the operational range from 3,5 kPa to 202 kPa. The effective area was determined in May 2004 by the pressure laboratory of Daco (UKAS accreditation number 0173), and the masses of the weights by Druck Standards Laboratory (UKAS accreditation number 0221).

The measurements on the Vaisala barometer were carried out on the 28th of September 2004 using the same procedure as in MIKES. The results and the uncertainties were given in the calibration certificate No. K001-02-04/789K and they are also shown in Table 2.

2. 4 Comparison of the results

The results from MIKES and Metrosert are illustrated in Fig. 1.

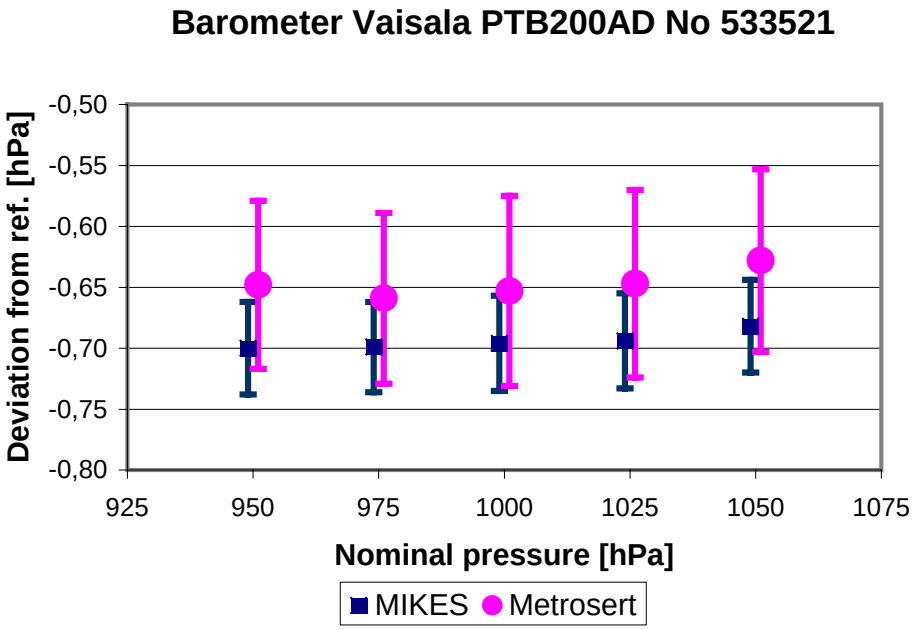

Figure 1. Comparison of the results in barometer calibration.

A tool often used in comparing the results from two sources A and B is the normalised error E_n. [4]. It takes into account both the measurement result and the uncertainty. The normalised error E_n for the each measurement is calculated as:

$$E_n = \frac{(result_A - result_B)}{\sqrt{U_{resultA}^2 + U_{resultB}^2}}$$

where $U_{resultA}$ and $U_{resultB}$ are the uncertainties, respectively.

In this case the result of Metrosert was compared to the average of the two MIKES results, and the E_n-values were calculated as

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

The factors $(p_{transfer} - p_{std})$ are the deviations recorded at each nominal pressure at both laboratories, and the values U are the uncertainties. The coverage factor in the uncertainty values is k = 2. The E_n-values for each measurement series are shown in Table2.

The two results in comparison can be regarded as equivalent if $|E_n| < 1$. This is the case for all the results.

Table 2. Comparison of the results in barometric range

Nominal pressure hPa	MIKES average hPa	Uncertainty of MIKES avg. hPa	Metrosert result hPa	Uncertainty of Metrosert hPa	E(n)
950	-0,700	0,038	-0,648	0,069	0,66
975	-0,699	0,037	-0,659	0,070	0,51
1000	-0,696	0,039	-0,653	0,078	0,49
1025	-0,694	0,039	-0,647	0,077	0,54
1050	-0,682	0,038	-0,628	0,075	0,64

3 Comparison in the gauge pressure range 0,5 MPa to 1,75 MPa

3. 1 Transfer standard

The transfer standard in this comparison was a DH Instruments pressure balance model PG7601 equipped with a piston cylinder unit No. 620 with the nominal effective area of 196 mm^2 and the pressure range 25 kPa to 1,75 MPa. The balance body has been used in MIKES for several years, but the piston cylinder unit was purchased in January 2004.

The manufacturer's value for the effective area at 20˚C of the unit No. 620 is

$$A_{20} = 196,1208\ mm2 \pm 0,0022\ mm^2\ (k = 2).$$

This is the average value for the range 50 kPa to 1,75 MPa (calibration report No. 33786 dated 13th of January 2004). The calibration laboratory of DH Instruments, Inc. is accredited by the American Association for Laboratory Accreditation (A2LA). The best uncertainty in calibrating the effective area of a piston cylinder is as low as 7 ppm in the range from 5 kPa to 1,75 MPa [1].

In MIKES the effective area of the unit No. 620 has been determined two times in gauge mode. The first calibration was made in February and the second in June 2004.

3. 2 Measurements in MIKES

The first measurements in February were made using a Desgranges & Huot 5203 an oil lubricated gas pressure balance as standard. The effective area of its piston cylinder unit was calibrated in BNM-LNE in November 2001 and was nominally 98 mm^2.

The measurements on the transfer standard covered the range 0,5 MPa to 1,75 MPa, and the effective area was determined as

$$A_{20} = 196,1202\ mm^2 \pm 0,0039\ mm^2\ (k = 2),$$

and not dependent on pressure. The result is presented in certificate M-04P006.

In June the measurements were made using another pressure standard. Now the standard was a Desgranges & Huot 5111 gas pressure balance with the nominal effective area of 980 mm^2. The pressure range of this instrument is from 0,02 MPa to 1 MPa. The effective area was determined in BNM-LNE in July 2003.

Due to the limited range of the reference standard the measurements in June did not cover the full range of the object. The effective area in this range was determined as

$$A_{20} = 196,1184\ mm^2 \pm 0,0040\ mm^2\ (k = 2),$$

and not dependent on pressure. The result is presented in certificate M-04P048.

The average of the two MIKES results is

$$A_{20} = 196,1193\ mm^2$$

and the uncertainty of the average is taken as 0,0042 mm^2.

3. 3 Measurements in Metrosert

The Metrosert standard used in this comparison was a gas pressure balance manufactured by Pressurements, model T1400, with the nominal effective area of 80,6

mm^2.and the operational range from 0,02 MPa to 3 MPa. The effective area and the masses of the weights were determined in May 2004 by Druck Standards Laboratory (UKAS accreditation number 0221).

The measurements on the Vaisala barometer were carried out on the 28th and 29th of September 2004 in the range 0,5 MPa to 1,75 MPa. The result is presented in certificate K001-02-04/790K and it was

$$A_{20} = 196{,}1156\ mm^2 \pm 0{,}0089\ mm^2\ (k = 2)$$

and independent of pressure.

3. 4 Comparison of the results

Again the result of Metrosert was compared to the average of the two MIKES results. The results are illustrated in Fig. 2, where also the manufacturer's result is included.

The E_n-value obtained for the results of MIKES and Metrosert is E_n = -0,38 which means that the results can be taken as equivalent.

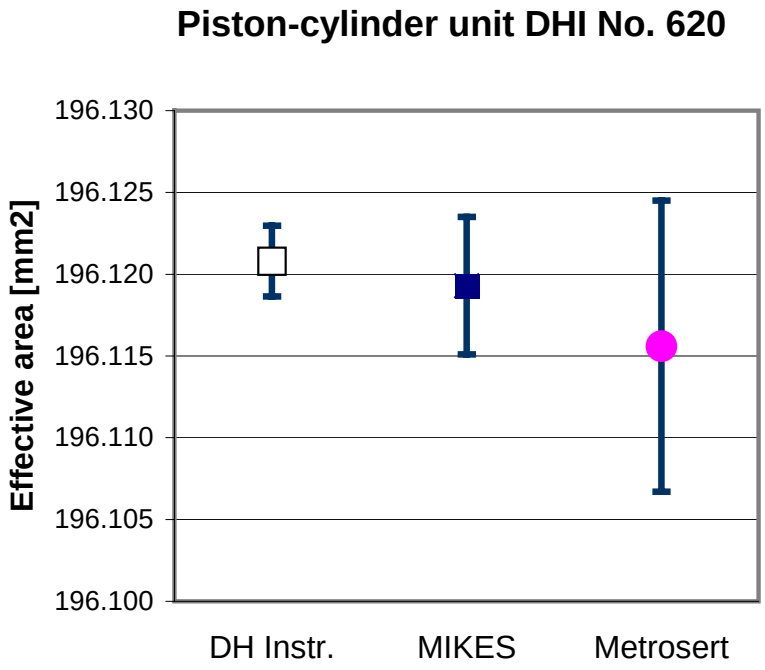

Fig. 2. Comparison of the results on determination of the effective area.

4 Conclusion

The agreement of the results of MIKES and Metrosert in both of the two comparisons was good.

References

[1] Certificate Number 1599.01, dated 27th of March 2003. The American Association for Laboratory Accreditation.

[2] Certificates of calibration M-04P006, M-04P048, M-04P078 and M-04P111. Centre for Metrology and Accreditation (MIKES). 2004.

[3] Certificates of calibration K001-02-04/789K and K001-02-04/790K. Metrosert 2004.

[4] Proficiency testing by interlaboratory comparisons. Part 1: Development and operation of proficiency testing schemes. ISO/ IEC Guide 43-1:1997

Recent publications

J5/2002 V. König, A. Pitkäkoski, M. Rantanen and S. Semenoja, *Comparison of spinning rotor vacuum gauges between MIKES, SP and Vaisala Oyj*

J6/2002 M. Rantanen and S. Semenoja, *Calibration of a 130 Pa CDG: Comparison of the results from MIKES PTB and MKS Deutschland*

J1/2003 J. Järvinen, M. Heinonen and A. Lassila (Eds.), *Annual Report 2002*

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J5/2003 K. Riski, *Mass comparison: 5 kg laboratory balance*

J6/2003 M. Rantanen, S. Semenoja *Comparison in absolute pressure range 0,02 hPa … 10 hPa between MIKES and Beamex*

J7/2003 M. Heinonen, *Comparison of dew-point temperature calibrations*

J8/2003 J. Järvinen (Toim.), *Kansallinen mittanormaalitoiminta ja sen kehittäminen 2003 - 2007*

J1/2004 J. Järvinen et al. (Eds.) *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.*

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