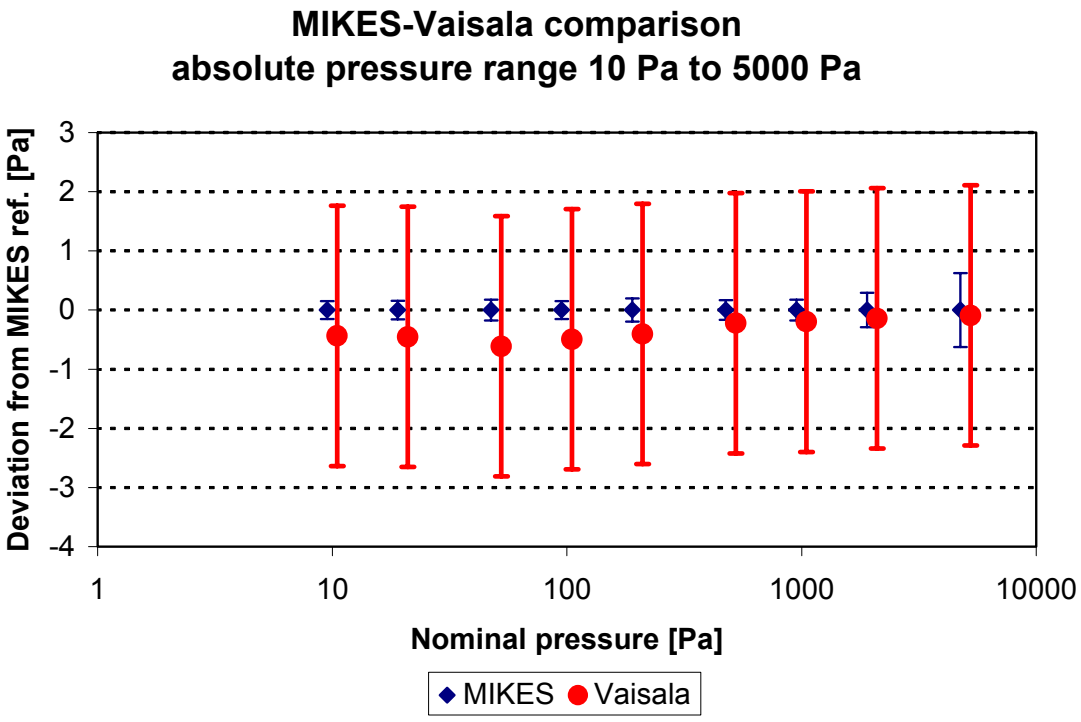
MIKES

METROLOGIA

J3/2007



Absolute pressure comparison between MIKES and Vaisala Oyj

Range 10 Pa to 5000 Pa

Markku Rantanen, Sari Semenoja & Jouni Leskinen

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Abstract

An absolute pressure comparison between the Centre for Metrology and Accreditation (MIKES) and the Measurement Standards Laboratory of Vaisala Oyj was arranged in February and March 2007. The comparison covered the range from 10 Pa to 5000 Pa.

The transfer standard was an MKS Baratron 100 torr type 690A12TRA pressure transducer with an MKS type 670B signal conditioner and display. The stability of the transfer standard was good.

All the pressure results from Vaisala Oyj were in a good agreement with the reference values from MIKES, calculated as averages of three subsequent calibrations made on different weeks.

Tiivistelmä

Mittatekniikan keskuksen (MIKES) ja Vaisala Oyj:n mittanormaalilaboratorion välinen absoluuttipaineiden vertailumittaus järjestettiin helmi-maaliskuussa vuonna 2007. Vertailu kattoi alueen 10 Pa – 5000 Pa.

Vertailulaite oli 100 torrin paine-eroanturi MKS Baratron 690A12TRA varustettuna näyttölaitteella MKS 670B. Vertailulaite oli hyvin stabiili mittausten aikana.

Kaikki Vaisalan mittaustulokset olivat mittausepävarmuuksien puitteissa samoja kuin MIKESin referenssiarvot, jotka laskettiin keskiarvoina kolmen eri viikkoina tehdyn kalibroinnin tuloksista.

Contents

1 Introduction

The Centre for Metrology and Accreditation (MIKES) is the National Metrology Institute in Finland. The pressure standards of MIKES cover the range from 0,5 mPa to 500 MPa. The pressure balances are traceable to Laboratoire National d'Essais (LNE), France, and the vacuum standards to Physikalisch-Technische Bundesanstalt (PTB), Germany.

The Measurement Standards Laboratory (MSL) of Vaisala Oyj has accreditation for pressure, temperature and humidity calibrations. The pressure balances of MSL are traceable directly to the National Institute of Standards and Technology (NIST), USA. In the absolute pressure range from 0,1 Pa to 5000 Pa the traceability is obtained from MIKES.

Pressure comparisons between MIKES and the Finnish accredited pressure calibration laboratories have been arranged on a regular basis.

2 Reference standard at MIKES

The reference standard of MIKES in the absolute pressure range from 20 Pa to 15 kPa is a DH Instruments FPG8601 digital piston manometer. The pressure is defined by means of the force measured by a high precision load cell and the effective area of the piston cylinder assembly. The nominal value of the effective area is 980 mm^2. The piston is not rotating, and it is maintained in the centred position by a constant lubricating flow through the annular gap.

The effective area is traceable to Laboratoire National d'Essais (LNE), Paris. The load cell of the instrument is calibrated with a weight set whose masses are traceable to the Mass laboratory of MIKES. The residual pressure in absolute pressure measurements is measured using a capacitance diaphragm gauge (CDG), traceable to PTB.

The instrument and its validation process are described in Reference 1.

The best measurement capability for the FPG8601 of MIKES in the absolute mode is estimated as 0,07 Pa + $4 \cdot 10^{-5} \cdot p$, where p is pressure in pascals. This CMC value was approved into the BIPM database in October 2005.

The FPG8601 can be operated in gauge mode as well.

3 Transfer standard

The transfer standard was an MKS Baratron 100 torr type 690ATRA12 absolute pressure transducer No. 96029363A with an MKS type 670B signal conditioner No. 238250. The resolution of the display is 0,1 Pa when *pascal* is selected as the unit on the signal conditioner.

The transducer has been used at MIKES as a working standard for about ten years. By the time some error has been developed in the output but the short term stability of the instrument is very good.

4 Measurement instructions

Measurement instructions for the comparison were simple. It was instructed to keep the transfer standard switched on for several hours, preferably overnight, before starting the calibration. Further, it was instructed to check and adjust the NUL and the FULL SCALE of the display. Finally, a pre-pressurisation twice over the range from 0 to 5000 Pa and the setting of the ZERO to 0,0 Pa was advised.

Otherwise both laboratories were free to use their own procedures. However, the following nominal pressures were recommended:

10 Pa, 20 Pa, 50 Pa, 100 Pa, 200 Pa, 500 Pa, 1000 Pa, 2000 Pa and 5000 Pa.

5 Measurements at MIKES and reference values

The transfer standard was calibrated three times at MIKES:

5.2.2007, certificate M-07P020
14.2.2007, certificate M-07P028
6.3.2007, certificate M-07P031.

Two calibrations were made before the measurements at Vaisala Oyj and one after.

The three calibrations at MIKES showed that the stability of the transfer standard was very good. The results of the MIKES measurements are shown in Table 1 and Figures 1 and 2. Each result point is the deviation of the transfer standard indication from the pressure defined by the MIKES standard:

Deviation = transfer standard indication – pressure from MIKES standard

Figure 2 illustrates the scatter of the results. Here the results are plotted as deviations from the average value of the results in the first MIKES calibration 5.2.2007. At high nominal pressures the scatter seems to be larger between the calibrations than inside one calibration. The hysteresis effects were negligible.

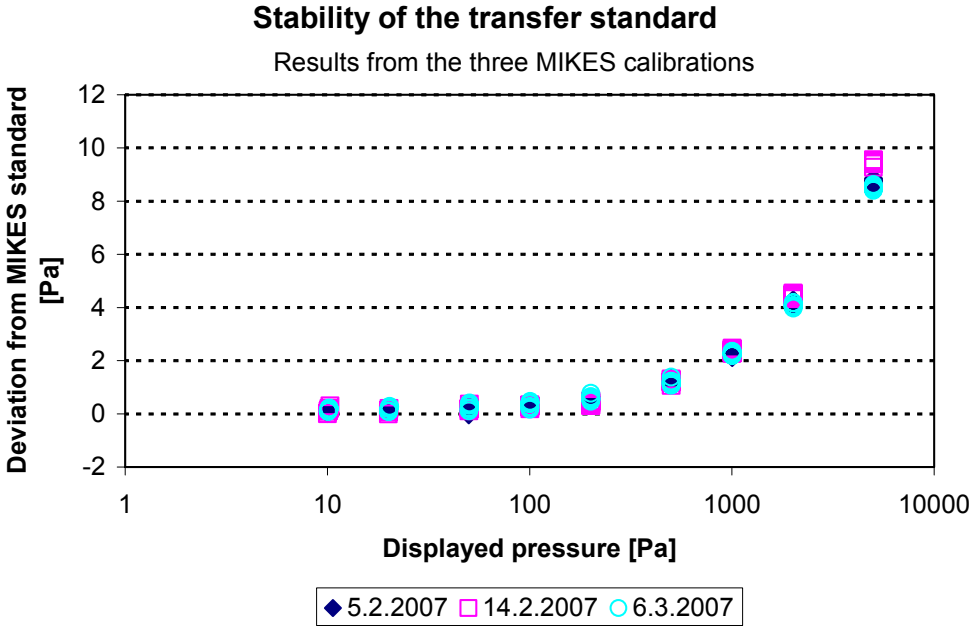

Fig. 1 Results from the three MIKES calibrations

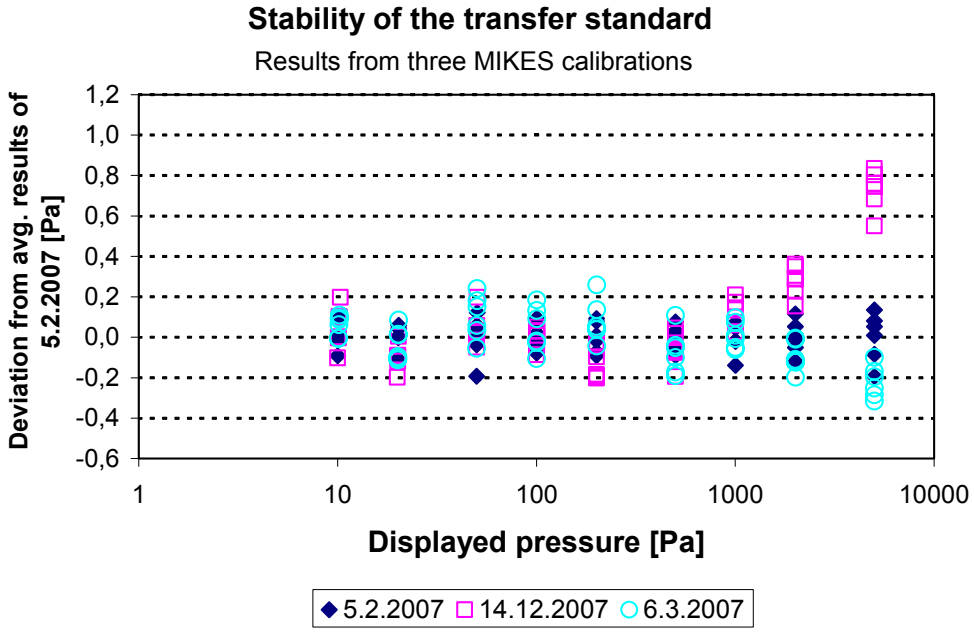

Fig. 2. Results from the three MIKES calibrations as deviations from the average results of the first calibration on 5.2.2007.

The reference values were calculated as average results of the three MIKES calibrations. The uncertainties of the reference values were based on the average uncertainties and the width of variation in the results, Table 1.

Table 1. Summary of the results from MIKES calibrations and the reference values

							REFERENCE VALUES	
	MIKES		MIKES		MIKES		Reference =	
Nominal	5.2.2007		14.2.2007		6.3.2007		average of	Uncertainty
pressure	Result	Unc.	Result	Unc.	Result	Unc.	MIKES results	of reference
Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa
10	0,10	0,14	0,15	0,16	0,16	0,14	0,14	0,15
20	0,20	0,14	0,10	0,14	0,16	0,15	0,15	0,15
50	0,16	0,17	0,21	0,15	0,27	0,17	0,21	0,18
100	0,28	0,14	0,28	0,14	0,32	0,17	0,29	0,15
200	0,52	0,15	0,39	0,15	0,60	0,17	0,50	0,20
500	1,27	0,15	1,21	0,16	1,19	0,17	1,22	0,17
1000	2,26	0,17	2,36	0,17	2,27	0,16	2,30	0,18
2000	4,18	0,19	4,46	0,19	4,08	0,19	4,24	0,29
5000	8,72	0,30	9,45	0,29	8,50	0,29	8,89	0,62

6 Measurements at Vaisala Oyj

The reference standards in the Measurement Standards Laboratory of Vaisala Oyj for the range from 10 Pa to 5000 Pa are two MKS Baratron capacitance diaphragm gauges of the type 627A12TCD, numbers 93215207A and 933571118A. The two gauges are used in parallel, and the average of their pressure readings is the standard value. An MKS SRG-2 No 20825G/92026G spinning rotor gauge is used for setting the zero.

The measurements at Vaisala Oyj on the transfer standard were carried out 26.2.2007. The results are shown in Table 2. The uncertainties of the results were estimated using the document EA-4/02 and a coverage factor k = 2.

Table 2 shows also a comparison of the results from Vaisala Oyj to the reference values from MIKES. The comparison is illustrated in Figure 3.

A tool often used in comparing results from two laboratories is the normalised error E_n, which takes into account both the difference between the results and their uncertainties. The normalised error E_n is calculated as

$$E_n = \frac{X_A - X_B}{\sqrt{\left(U_A^2 + U_B^2\right)}}$$

where X_A and X_B are the results from laboratories A and B and U_A and U_B the uncertainties, respectively.

Table 2. Vaisala results and comparison to MIKES reference values

	MIKES reference values		Vaisala 26.2.2007		Difference	Normalised
Nominal pressure	Reference value	Uncertainty of reference	Result	Uncertainty	from reference	error E(n)
Pa	Pa	Pa	Pa	Pa	Pa	
10	0,14	0,15	-0,3	2,2	-0,44	-0,20
20	0,15	0,15	-0,3	2,2	-0,45	-0,21
50	0,21	0,18	-0,4	2,2	-0,61	-0,28
100	0,29	0,15	-0,2	2,2	-0,49	-0,22
200	0,50	0,20	0,1	2,2	-0,40	-0,18
500	1,22	0,17	1,0	2,2	-0,22	-0,10
1000	2,30	0,18	2,1	2,2	-0,20	-0,09
2000	4,24	0,29	4,1	2,2	-0,14	-0,06
5000	8,89	0,62	8,8	2,2	-0,09	-0,04

Two results in a comparison can be regarded as equivalent within the limits of uncertainty, if E_n-values are between -1 and + 1. In this case all the E_n-values are between -0,28 and -0,04.

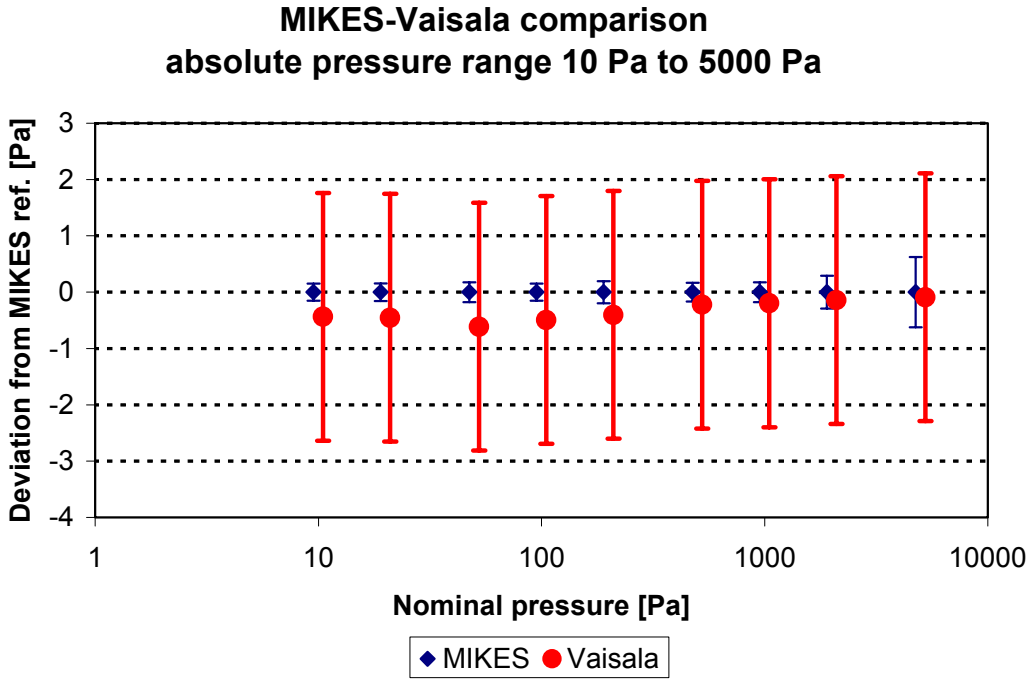

Fig. 3. Comparison of the results from MIKES and Vaisala Oyj

7 Conclusions

The results from the Measurements Standards Laboratory of Vaisala Oyj were in a good agreement with the reference values from MIKES.

The transfer standard, an MKS Baratron 100 torr type 690ATRA12 absolute pressure transducer with an MKS type 670B signal conditioner was found to be very stable.

8 References

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[2] EA-4/02: Expression of the Uncertainty of Measurement in Calibration
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