MITTATEKNIIKAN KESKUS

CENTRE FOR METROLOGY AND ACCREDITATION

Julkaisu J1/1999

NORDIC INTERCOMPARISON IN BAROMETRIC PRESSURE

Absolute pressure range 95 ... 105 kPa

Markku Rantanen

Helsinki 1999

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ABSTRACT

A Nordic intercomparison P12 in the barometric pressure range 95 … 105 kPa was arranged in 1998 by the Centre for Metrology and Accreditation (MIKES). Five national pressure laboratories, and nine accredited and five non-accredited pressure calibration laboratories from six countries participated in the comparison.

The transfer standard, a Vaisala PTB220TS barometer, was found to be very stable and insensitive to variations in the ambient temperature.

The results of the national laboratories MIKES, Flygtekniska Försöksanstalten (FFA), Sweden, FORCE Institute, Denmark, and Nederlands Meetinstituut (NMi), the Netherlands, were in a very good agreement with each other and with the low-uncertainty results from National Physical Laboratory (NPL), United Kingdom.

All the results from accredited laboratories were in a good agreement with the results from MIKES and with the results from NPL as well. In one of the non-accredited laboratories the comparison revealed an error in the calibration system. One or two other non-accredited participants should re-evaluate their calibration uncertainties.

CONTENTS

NORDIC INTERCOMPARISON IN BAROMETRIC PRESSURE

1 INTRODUCTION

A Nordic intercomparison P12 in the barometric pressure range 950 … 1050 hPa was arranged in 1998 by the Centre for Metrology and Accreditation (MIKES). Five national pressure laboratories, and nine accredited and five non-accredited pressure calibration laboratories participated in the comparison.

The accuracy of pressure measurements in the barometric range is important not only in meteorology and avionics but in most fields of metrology as the results generally need to be corrected for the ambient air pressure.

2 TRANSFER STANDARD

The transfer standard was a Vaisala PTB220TS barometer s/n RD469733, made available by Vaisala Oyj. The operating range of this instrument is 500 … 1100 hPa, and the resolution of the display 0,01 hPa.

Before starting the circulation, the pressure laboratory of Vaisala Oyj introduced a small pressure-dependent error into the transfer standard.

3 REFERENCE LABORATORY

The reference standard for the barometric range in the pressure laboratory of MIKES is a Desgranges & Huot 24610 digital pressure balance. The effective areas of the pressure balances of MIKES are traceable to Laboratoire National d'Essais (LNE), Paris. The reference vacuum gauges are traceable to Flygtekniska Försöksanstalten (FFA), Stockholm.

4 PARTICIPANTS

The intercomparison started as a joint national comparison in Finland and Sweden. Later, six laboratories from Denmark, Norway and the Netherlands joined in. As the transfer standard stability was found to be very good, the comparison was finally completed with results from NPL, one of the leading pressure laboratories in the world.

In addition to MIKES, four other national pressure laboratories participated in the comparison:

Laboratory	*Contact person*
Flygtekniska Försöksanstalten (FFA), Sweden	Carin Bergström
FORCE Instituttet, Denmark	Lene Schou Sørensen
Nederlands Meetinstituut (NMi), the Netherlands	J. C. G. A. Verbeek
National Physical Laboratory (NPL), UK	Michael Perkin

The list of other participants is below:

Finland (7):
Finnair Oy Test Equipment Calibration *)
Finnish Air Force Depot, Central Repairshop, Calibration Laboratory
Finnish Meteorological Institute*)
Inspecta Oy Measuring Technology *)
IVO Technology Center, Calibration Services
Oy Beamex Ab, Calibration Laboratory
Vaisala Oyj, Measurement Standards Laboratory

Denmark (1):
Danish Aerotech, Karup Air Base

Norway (3):
FIMAS Kalibreringssenter
IKM Laboratorium AS
Norwegian Meteorological Institute *)

Sweden (3):
ABB STAL Calibration Laboratory
SAAB AB Mätteknik
Swedish Meteorological and Hydrological Institute *)

*) Laboratory or barometric range not accredited

5
STABILITY OF THE TRANSFER STANDARD

During the intercomparison the transfer standard was calibrated five times in the reference laboratory. The first calibration was made at the end of March 1998 and the fifth in the middle of November 1998. The stability of the instrument was found to be very good. Figure 1 shows all the results of MIKES. The width of the scatter band is less than 3 Pa. This value, of course, includes variations due to the reference standard of MIKES. Thus, 0,75 Pa is used as a rough estimate for the standard uncertainty due to the unstability of the transfer standard.

The good stability of the transfer standard was confirmed by six calibrations in the accredited pressure laboratory of Vaisala Oyj. The reference standard of Vaisala is a Ruska type 2465 pressure balance. On the contrary to the other accredited pressure laboratories in Finland, the pressure laboratory of Vaisala is not traceable to MIKES in the barometric range but to the National Institute of Standards and Technology (NIST), USA. Both the effective area of the Ruska balance piston-cylinder unit and the reference vacuum gauge are regularly calibrated at NIST. In fact, the pressure laboratory of Vaisala is today able to reach slightly lower uncertainty than MIKES in the barometric range. The width of the scatter band in the six Vaisala calibrations was only 2 Pa.

Further, the stability of the transfer standard was confirmed by the results from other national pressure laboratories. The calibration at NPL was performed against their best mercury column manometer. Consequently, the uncertainty of the NPL calibration was much lower than that of the other participants.

All the results from national pressure laboratories were in a good agreement. A summary of the results on three nominal pressures are shown in figures 2 – 4.

In addition to the calibration of the transfer standard at temperature +20°C, NMi made some measurements at +17°C and +23,5°C to check the effects of temperature variation. The temperature sensitivity of the pressure indication was negligible, within the resolution of the instrument.

6
MEASUREMENT INSTRUCTIONS

The participants were asked to keep the transfer standard turned on for at least 8 hours, and then to calibrate the instrument by comparing its readings to those of the laboratory standard at nominal pressures 950 hPa, 975 hPa, 1000 hPa, 1025 hPa and 1050 hPa, first in increasing and then in decreasing direction and following the laboratory's own procedures. This measurement cycle was to be repeated at least three times.

Further, the participants were asked to present the results as a calibration certificate and to send it to FINAS (the Finnish Accreditation Service) within two weeks after the measurements.

7 RESULTS

Following the EA intercomparison practice all laboratories (except the national ones and Vaisala) were given letter codes. Each laboratory knows only its own code.

A summary of all the result is shown in Appendix 1. The results on the decreasing pressure 1000 hPa are illustrated in figures 5 and 6.

A tool often used in analysing results from interlaboratory 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.

In the first place, the E_n -values were calculated using the MIKES average values as references. The uncertainty of the reference values was calculated by combining the calibration uncertainty (4,6 to 4,9 Pa, depending on pressure) with the estimated uncertainty due to unstability (1,5 Pa). The coverage factor is k = 2.

Additionally, an advantage of the low uncertainty results from NPL was taken by using them as reference values for the results from national laboratories. Even here the estimated uncertainty due to unstability (1,5 Pa) was combined with the calibration uncertainty (1,5 Pa).

The E_n-values of all the results are shown in Appendix 1.

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

National laboratories + Vaisala

Laboratory code	MIKES as reference range of E_n-values	NPL as reference range of E_n-values
MIKES (M5)	0,13 … 0,23	0,10 … 0,27
Vaisala (V5)	-0,03 … 0,12	-0,07 … 0,07
FFA	-0,31 … 0,24	-0,69 … 0,36
FORCE	0,07 … 0,26	0,00 … 0,31
NMi	-0,10 … 0,16	-0,18 … 0,13

Accredited laboratories

Laboratory code	MIKES as reference range of E_n-values	NPL as reference range of E_n-values
b	0,09 … 0,18	0,09 … 0,15
c	0,06 … 0,13	0,04 … 0,12
e	-0,38 … 0,25	-0,41 …-0,30
h	-0,60 …-0,45	-0,61 …-0,46
i	-0,24 …-0,14	-0,29 …-0,15
j	-0,39 …-0,10	0,60 …-0,22
k	0,25 … -0,35	0,23 … 0,38
l	0,00 … 0,07	-0,01 … 0,05

Non-accredited laboratories

Laboratory code	MIKES as reference range of E_n-values	NPL as reference range of E_n-values
a	-0,56 …-0,38	-0,61 …-0,43
d	-0,21 … 0,02	-0,31 …-0,04
f	-0,10 …-0,03	-0,11 …-0,04
g	-0,67 …-0,27	-1,83 …-0,33
m	1,20 … 1,31	1,33 … 1,49

The result in an interlaboratory 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 all the absolute E_n-values for national and accredited laboratories are less

than 1 – in fact less than 0,7 – in comparison to both MIKES and NPL reference values.

The value $E_n = 1$ is exceeded only for the results from the non-accredited laboratories **g** and **m**.

The results from **g** do not differ much from the reference values but the claimed uncertainty is unrealistically low.

After receiving the preliminary reference values, the laboratory **m** checked their measurement system, and found and corrected an error. Now the agreement should be better.

The E_n-values of the laboratory **f** are acceptable as such, but the result shows perhaps an opportunity to reconsider and reduce uncertainties.

It is clear that the group of non-accredited laboratories is less familiar with the calculation of uncertainties and with the expression of uncertainty according to the EA documents.

8 CONCLUSIONS

Five national pressure laboratories, and nine accredited and five non-accredited pressure calibration laboratories from six countries participated in an intercomparison in the barometric range 950 … 1050 hPa between March and November in 1998. The following conclusions can be drawn:

The transfer standard, a Vaisala PTB220TS barometer, was found to be very stable and insensitive to variations in the ambient temperature.

The results of the national laboratories MIKES, FFA, FORCE Institute and NMi as well as the results of Vaisala were in a very good agreement with each other and with the low-uncertainty results from NPL.

All the results from accredited laboratories were in a good agreement with the reference values from MIKES and with the reference values from NPL as well.

In one of the non-accredited laboratories the comparison revealed an error in the pressure calibration system. The error was corrected and a better agreement should be reached now. As for two other non-accredited laboratories, a re-evaluation of the uncertainties is proposed; one should increase the uncertainties and the other may have an opportunity to reduce them.

8
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MITTATEKNIIKAN KESKUS
PL 239
00181 HELSINKI
Puh. (09) 616 761 (vaihde)
Telekopio (09) 616 7467

CENTRE FOR METROLOGY AND ACCREDITATION
P.O. Box 239
FIN-00181 HELSINKI
Tel. +358 9 616 761
Telefax +358 9 616 7467

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