Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC pressure 2024:1) rev 2

The bag carrying 2 pieces of equipment for calibration.

Author

Håkan Källgren
Swedish Metrology and Quality AB

Content

Abstract

This report is about a calibration inter-comparison of two pressure sensors with 16 participating laboratories. Both pressure gauges were calibrated with 4 pressure levels.

These data were provided in two ways, as an excel protocol and with some delay as a calibration certificate. The calibration certificates are the base for all evaluations except in 2 cases where the laboratories wanted to use the Excel-sheets because they want to prove better CMC values for the accreditation bodies,

Most participants delivered results for all asked obligatory calibration points. But several could not reach some pressure points.

Before start and after the end of the comparison both sensors were also calibrated by RISE (Swedish national metrological institute.

In most comparison situations, the reference uncertainty was clearly lower than that of the participants, which gives those results necessary credibility. However, that is not a result in all cases was the reference uncertainty a third of that of a participant's laboratory as would be wished for.

Many uncertainty claims are comparable, but four or five reports give considerably larger values than the majority. This report covers calibrations made by 17 laboratories in 9 countries and mostly using their local languages.

Calibration certificates were sent to the organiser approximately one week later. The certificates were delivered in the language the laboratory uses in their work.

The summarized results are as follows:

Stability checks during circulation demonstrated that the equipment was stable as can be seen below.

Purpose and implementation of the comparison

This interlaboratory comparison serves as a tool to verify results from the measurement carried out by calibration laboratories. It is an effective method to demonstrate technical capacity of the participant and serves as a technical base for accreditation as required by ISO/IEC 17025:2017 (SS-EN ISO/IEC 17025:2018) as specified in point 7.7.2.

Advisory group

The intercomparison has followed the recommendations of the advisory group. The advisory group has defined the set-up of instruments that should be included in the ILC pressure 2024:1 intercomparison as well as the choice of measuring points that are defined to be included in the evaluation of the results.

The advisory group consists of Aykurt Altintas, Force Technology Denmark and Håkan Källgren Swedish Metrology and Quality. This intercomparison is based on previous decisions by the advisory group for pressure intercomparisons.

Information about the intercomparison

The information about the intercomparison was done in 3 different media:

- Linkedin
- The data base https://www.eptis.org
- On the web https://smquality.se/interlaboratory-comparisons-ilc

The information on the web was done in 2 steps. General information as ILC pressure 2021:1 published on smquality.se and enclosed to this report in annex 1

Detailed information as a description of the intercomparison/ILC published on smquality.se
and enclosed to this report.as annex 2.

Calibrated objects

The 2 instruments above were sent in one parcel and participants could choose which object they wanted to calibrate.

Participating laboratories and measuring scheme for the comparison

Laboratory	**Country**
RISE, reference laboratory	Sweden
Nordtec Instrument AB	Sweden
Halstrup-wacher GmbH	Germany
BlowerDoor GmbH	Germany
Tecyges S.L.	Spain
Dimed NV	Belgium
LHM Instrumentation	Belgium
METROSERT	Estonia
Danish Technology Institute	Denmark
METLAB miljö AB	Sweden
MVM Paksi Atomerömy	Hungary
CETIAT	France
ISCAL	Spain
Element Metech A/S	Denmark
Element Metech AB	Sweden
RISE Research Institutes of Sweden AB	Sweden
Sondar.i - Laboratório de Efluentes Gasosos	Portugal
RISE, reference laboratory	Sweden

There were some delays at the end of circulation as some laboratories wanted to join even if the project had stopped. The circulation ended in week 44 in 2024.

Most of the participants have an accreditation by COFRAC, DAkkS, BELAC, DANAK, ENAC. RVA, EAK, NAH, and SWEDAC,

All laboratories are not yet accredited but will use this ILC as a base to apply for accreditation.

The reference laboratory has the status as a National Metrology Institute, NMI.

Principles concerning the calibration in general.

The reference laboratory calibrated both pressure devices prior to the first and after the last participant calibrations.

A preliminary check after several calibrations was performed to find out if there was a possible drift. The purpose was to achieve as equal conditions as possible for all participants over the total measurement period. No drift occurred outside the uncertainty reported from the reference laboratory as reported under supporting checks of stability below.

Conditions and transport during the measurement period

A special case having special filters and insulation for humidity and vibrations was used for transport.

Calibration instructions

The laboratories were allowed maximum 5 days for each calibration. In the call they were advised to use their own calibration procedures with focus on the points described below which were important for the inter-comparison outcome. They were not allowed to perform any type of adjustment on the objects. This task was reserved for the reference laboratory.

Using own procedures also meant it was up to the laboratories which measurement points over the compulsory ones they would include.

The laboratories further were encouraged to use the actual calculated uncertainty values even if those would differ from the CMC values in their accreditation.

Compulsory calibration points

Differential pressure Range: 0-250 Pa,
Calibration points: - 250, -200, -150, -100, -50, -20, 0, 20, 50, 100, 150, 200, and 250 Pa

Differential pressure Range: 0 – 2500 Pa
Calibration points: -2500, -2000,-1500, -1000, -500, 0, 500, 1000, 1500, 2000,and 2500 Pa

Planning and instruction details

The laboratories were asked to send the original calibration data directly after finishing the calibration in digital form by e-mail. The final calibration certificate should then be sent to the organizer within one week. Most participants also managed to deliver in time.

The evaluator used the principles of the ISO/IEC 17043:2023 in the reporting.

Administrative information

Address to send the required documents:
Swedish Metrology and Quality AB Håkan Källgren Dragspelsgatan 21 SE-504 72 Borås, Sweden e-mail: hakan.kallgren@smquality.se Phone: +46 705 774 931

Summary of the timeline planning in the call:

- The preliminary results should be sent to the organiser when the parcel was sent to next participant.
- One week after the calibration/measurement send the calibration certificate to the evaluator of the intercomparison.
- A draft report should be sent to the participants 2 weeks after receiving the last calibration certificate. The organiser was not able to deliver according to this rule.
- Comments on the draft report to the organiser within 1 week
- Final report should be finalized within 2 weeks after receiving comments from all participants.

Analysis of the calibration results

The main information compared is the error of indication at all measurement points found by the participants. It is simply the difference between the displayed pressure on the pressure gauge under calibration and the pressure read from a calibrated reference equipment (International vocabulary of metrology – Basic and general concepts and associated terms (VIM) 2.53).

The quality of each individual measurement result is reviewed using the En – criteria. For each measurement point it is the distance of respective laboratory result to the corresponding assigned comparison reference value normalised with respect to the uncertainty in determining this difference.

$$E_n = \frac{x_i - x_{ref}}{\sqrt{U_i^2 + U_{ref}^2}}$$

x_i: Single measurement result (error of indication); index i counts the various participants.

x_{ref}: Assigned inter-comparison reference value.

U_i: The estimated expanded uncertainty (k=2) stated by each laboratory for respective calibration point.

U_{ref}: The estimated expanded uncertainty (k=2) of the assigned reference value for the same calibration point.

Inter-comparison reference value and its uncertainty

The chosen reference laboratory supplied 2 complete calibrations for both instruments at the stipulated pressure levels Both calibrations before the start and the other after the end of the comparison included 2 series each. The assigned reference values at all calibration points are composed (equation 1) as the average of these four results at each pressure level.

$$R_{l,m} = (R1 \ \& \ R2) = \frac{1}{4}\sum_{l=1}^{4} Ei_{l,m} \quad \text{(eq. 1)}$$

For each instrument

$R_{l,m}$: The calculated inter-comparison reference value for pressure level *m*.
Ei: The measured error of indication by the reference laboratory.
Index l: Counts the measurement series (I = 1 and 2 from the first and l = 3 and 4 from the last calibration).
Index m: Specifies the pressure level 1 to 6 at increasing and 7 to 12 at decreasing pressure.
R1 & R2: In the result tables used for identifying the comparison reference, in the diagrams *R* is used.

At some calibration points the reported uncertainties differed slightly between the two calibration opportunities. Thus, the measurement uncertainty for each calibration level was calculated as the uncertainty of the mean (equation 2).

$$U_m = \frac{\sqrt{U_{s,m}^2 + U_{f,m}^2}}{\sqrt{2}} \qquad \text{(eq. 2)}$$

For each instrument

Um: The combined uncertainty from two calibrations (at different pressure levels *m*).
Index s: Refers to the calibration at start.
Index f: Refers to the final calibration.

Given the same uncertainty for a pressure level at start and at the end the uncertainty of the reference value is identical with that stated by the laboratory in one of the calibrations. Otherwise, the reference uncertainty lies in the middle of both.

The data supplied by the reference laboratory indicated a small drift which, however, always was within the stated uncertainty. Half of this drift was added linearly to compose the assigned reference uncertainty (equation 3) for each pressure level.

The uncertainty of the inter-comparison reference value was the composed by adding half of the detected drift over the time for the total exercise.

$$U_{ref,m} = U_m + abs\left(Ei_{f,m} - Ei_{s,m}\right) \qquad \text{(eq. 3)}$$

Results in relation to the estimated reference values

Calibration Point/Pressure	CMC	Possible uncer-tainty(U)*	Resulted uncer-tainty (U)
Pa	Pa	Pa	Pa
Object 1			
-250	0,098	0,10	0,1145
-200	0,094	0,10	0,101
-150	0,091	O,10	0,106
-100	0,087	0,09	0,097
-50	0,084	0,09	0,097
-20	0,084	0,09	0,086
0	0,08	0,08	0,084
20	0,084	0,09	0,091
50	0,084	0,09	0,090
100	0,087	0,09	0,091
150	0,091	0,10	0,101
200	0,094	0,10	0,096
250	0,098	0,10	0,115
Object 2			
-2500	0,26	0,26	0,292
-2000	0,22	0,22	0,278
-1500	0,19	0,19	0,204
-1000	0,08	0,15	0,169
-500	0,12	0,12	0,120
0	0,08	0,08	0,084
500	0,12	0,12	0,138
1000	0,15	0,15	0,194
1500	0,19	0,19	0,217
2000	0,22	0,22	0,311
2500	0,26	0,26	0,318

*Including possible drift during the circulation

Traceability for the reference values R1 and R2 at each point

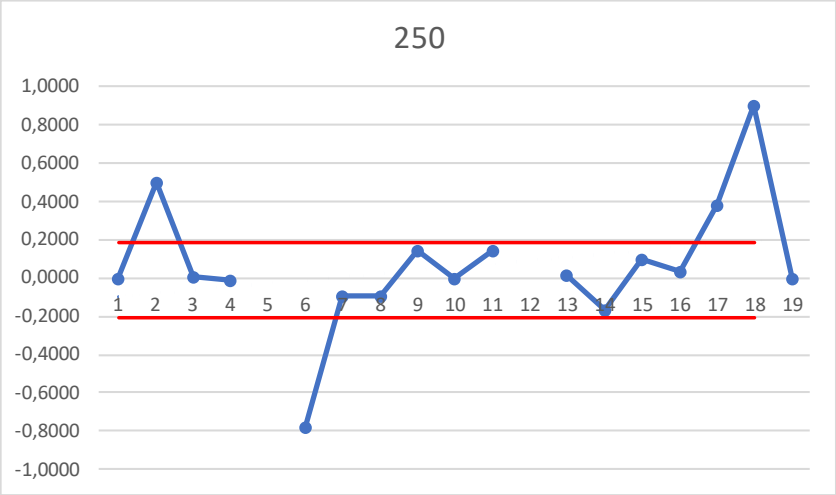
The traceability was established by the Swedish National Research Institute, RISE by the two calibrations of the equipment (105102-1247333-K01 and 105102–1247333-K02 before the circulation.

The second calibration was done by the reference laboratory after the circulation and documented by calibration certificates number 105102-1258941-K01 and 105102-1258941-K02 after the circulation.

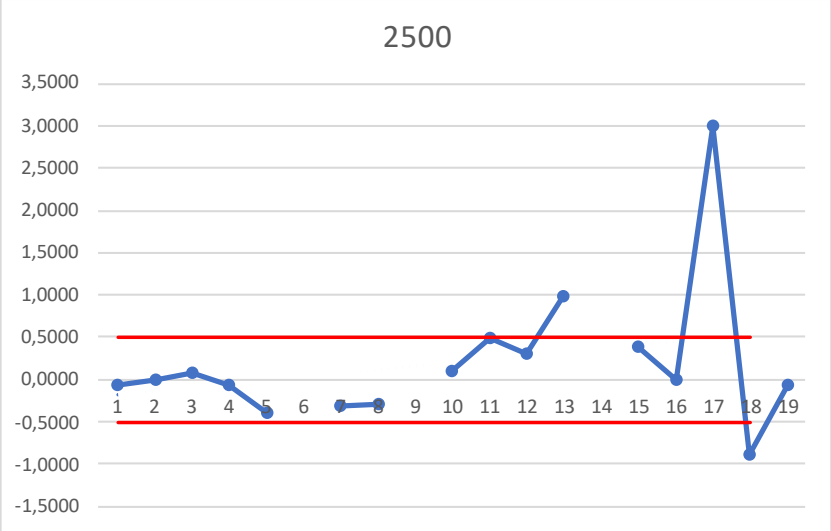
Supporting checks of stability

The stability of both sensors over the time of the comparison was monitored by following up the reported indication error immediately after each participant had finished its calibration. The diagrams below show the error indication values for sensor 1 in timely order with the first and last symbol referring to the reference laboratory. The two dashed lines imply a ±2 *Um*-band from *R1m*. The dotted line is a prognostic trendline which is automatically updated every time a new result is added. The idea behind was to be able to react fast and recall the calibration object for a new reference calibration, if necessary, before a consecutive participant would perform the next measurement.

Stability checks 250 Pa



Stability checks 2500 Pa



The principle of the intercomparison

An absolute value of E_n of less than 1 is often used as a criterion for an acceptable measurement quality, according to ISO/IEC 17043:2010, B.4.1.1.

Measuring results on calibration in the ILC

The following tables and diagrams present the error of indication along with the stated measurement uncertainty for each calibration point. Besides the interesting “error” and “uncertainty” also the reported “reference pressure” and the “reference uncertainty” are listed in the following tables.

It was the ambition of the organizer to directly incorporate the various excel-protocols into the calculation for reporting the outcome of the comparison measurements after first having checked all data against those in the calibration certificates delivered afterwards. This worked mostly very well. One laboratory did not deliver a calibration certificate to check the excel-data against.

The participation numbering 1 to 17 is arbitrary and not in time order of calibration. This assigned identity is kept the same throughout the whole report. Some participants only delivered results for instrument 1, others only for instrument 2. Those participants do not appear in the tables or diagrams. Empty lines in the tables indicate instead that for those points no calibration values were provided.

Some participants specified data on some other pressure levels in their calibration. This part of the comparison is, however, not evaluated in this report.

The following tables are built with increasing participant identity numbers and list at the bottom the belonging reference value “error” and uncertainty “U” based on the average of two calibrations by the reference laboratory.

Both instruments were new and not in use before the inter-comparison.

The principle in the diagrams is that the dot is pointing at the result and the vertical line is uncertainty. This demonstrates the big difference in uncertainty levels by the different laboratories,

Observe that the uncertainty is documented by 3 significant digits instead of 2 as the standard requires because of that checking the results shall not be affected by the rounding effect.

Table 1 -250 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	-0,20	0,16	1,02
2	-0,02	0,50	0,04
3	-0,47	1,21	0,39
5	-0,13	0,33	0,37
6	0,75	4,15	0,18
7	0,03	0,43	0,07
8	-0,028	0,059	0,22
9	-0,053	0,069	0,40
11	-0,2	0,51	0,38
12	-0,14	0,42	0,32
13	0,14	0,80	0,17
14	-0,04	0,40	0,10
15	0,04	5,2	0,01
16	-0,06	0,10	0,39
17	-0,041	0,072	0,30
	Ref error	Ref Uncertainty	
	0,0000	0,115	

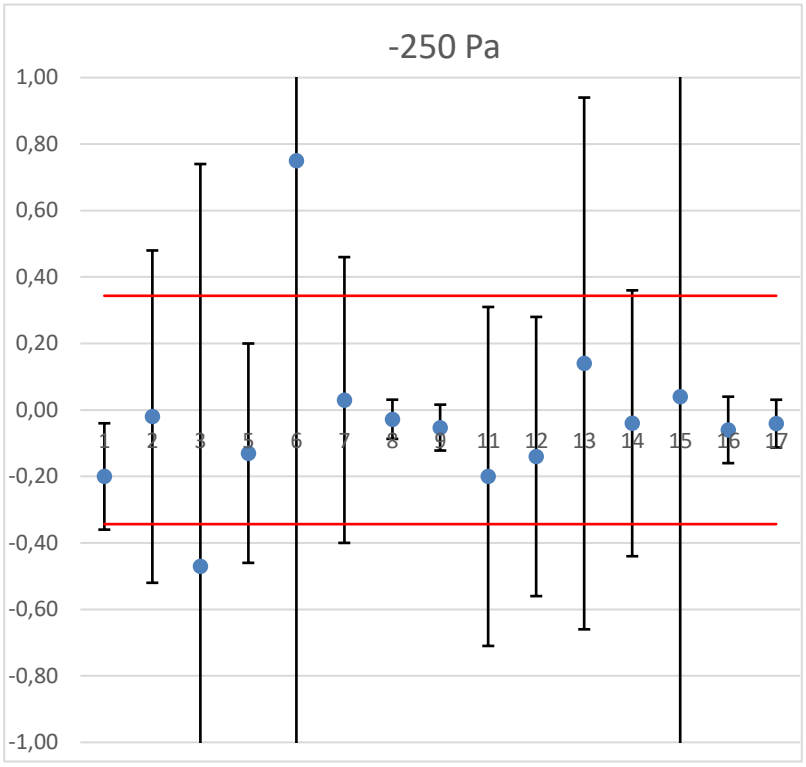


Table 2 -200 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	-0,16	0,15	0,70
2	-0,02	0,50	0,03
3	-0,58	1,19	0,46
5	-0,03	0,32	0,01
6	0,54	3,80	0,15
7	0,08	0,40	0,27
8	-0,034	0,060	0,01
9	-0,043	0,069	0,08
11	-0,2	0,41	0,40
12	-0,12	0,42	0,20
13	0,07	0,80	0,13
14	-0,08	0,35	0,13
15	0,55	5,0	0,12
16	-0,037	0,095	0,03
17	-0,027	0,062	0,05
	Ref error	Ref Uncertainty	
	-0,033	0,101	

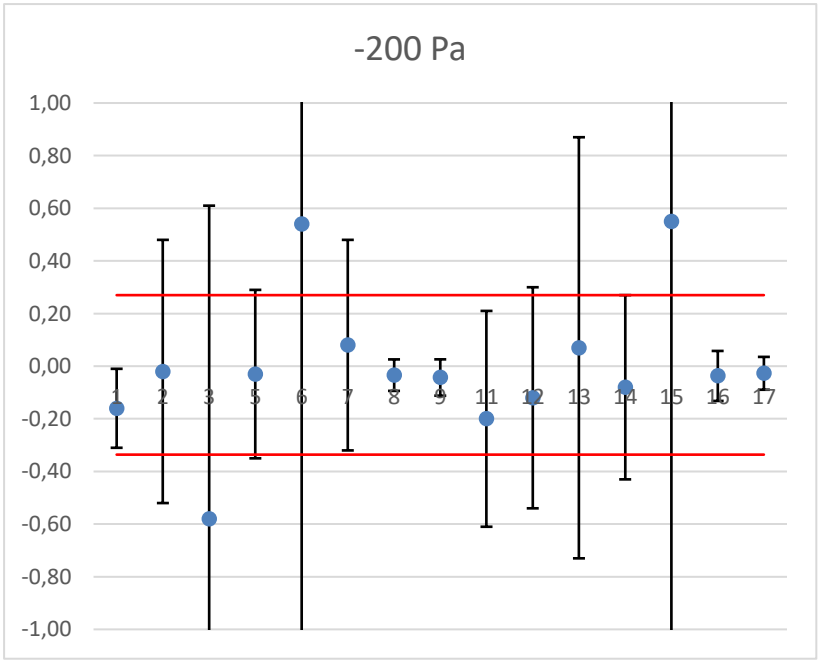


Table 3 -150 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	-0,14	0,14	0,59
2	-0,02	0,50	0,03
3	-0,41	1,19	0,31
5	-0,10	0,29	0,21
6	0,39	3,45	0,12
7	0,05	0,38	0,22
8	-0,03	0,076	0,02
9	-0,031	0,061	0,04
11	-0,1	0,31	0,20
12	-0,10	0,42	0,15
13	0,06	0,80	0,12
14	-0,07	0,30	0,11
15	0,46	4,7	0,11
16	-0,043	0,089	0,05
17	-0,015	0,081	0,16
	Ref error	Ref Uncertainty	
	-0,036	0,106	

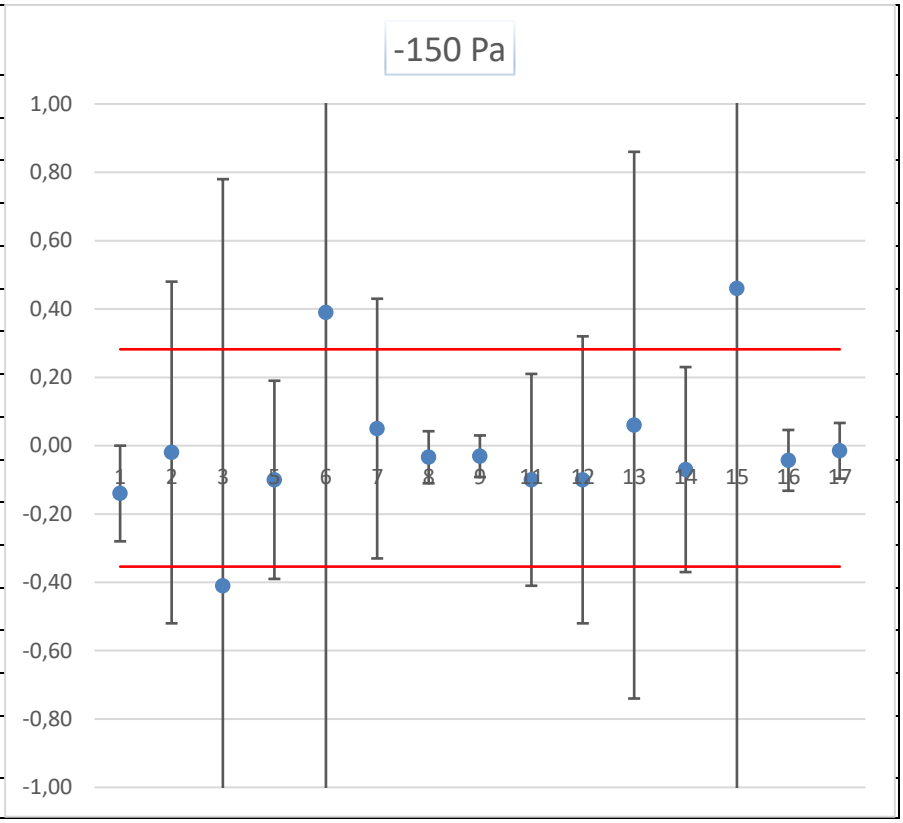


Table 4 - 100 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	-0,10	0,14	0,51
2	-0,01	0,50	0,01
3	-0,28	1,19	0,22
5	-0,05	0,26	0,13
6	0,26	3,10	0,09
7	-0,06	0,35	0,13
8	-0,017	0,069	0,03
9	-0,009	0,057	0,04
11	0,0	0,31	0,04
12	-0,1	0,42	0,16
13	0,04	0,80	0,07
14	-0,06	0,25	0,18
15	0,07	1,8	0,05
16	0,000	0,083	0,10
17	-0,005	0,081	0,06
	Ref error	Ref Uncertainty	
	-0,013	0,097	

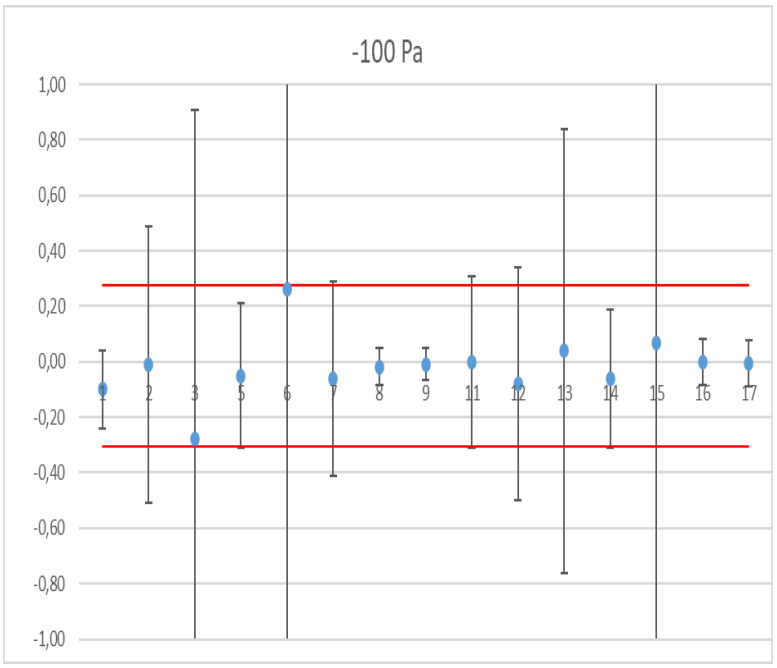


Table 5 -50 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	-0,05	0,13	0,33
2	0,00	0,50	0,00
3	-0,12	1,19	0,10
5	-0,03	0,26	0,12
6	0,11	2,75	0,04
7	-0,07	0,33	0,21
8	-0,017	0,079	0,16
9	-0,004	0,054	0,06
11	0,0	0,31	0,01
12	-0,06	0,42	0,14
13	0,00	0,80	0,00
14	-0,06	0,21	0,27
15	0,08	1,5	0,05
16	-0,023	0,089	0,20
17	0,013	0,066	0,10
	Ref error	Ref Uncertainty	
	0,002	0,092	

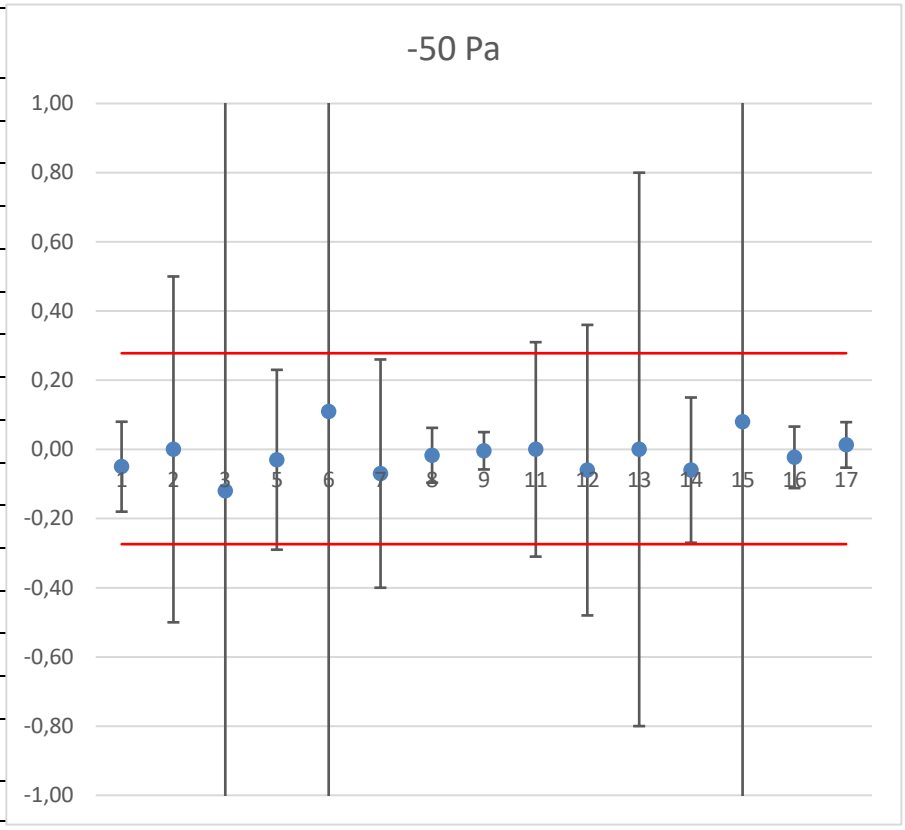


Table 6 -20 Pa, Results and diagram

	Table	-20 Pa	
Identification	Error	Uncertainty	En value
1	-0,07	0,13	0,50
2	0,00	0,50	0,02
3	0,00	1,19	0,01
5	0,08	0,26	0,26
6	0,03	2,54	0,01
7	-0,03	0,31	0,12
8	-0,019	0,069	0,25
9	0,002	0,052	0,06
11	0,0	0,31	0,03
12	-0,06	0,42	0,16
13	0,00	0,80	0,01
14	-0,09	0,17	0,52
15	0,08	1,3	0,05
16	-0,012	0,091	0,16
17	-0,005	0,075	0,12
	Ref error	Ref Uncertainty	
	0,0085	0,0855	

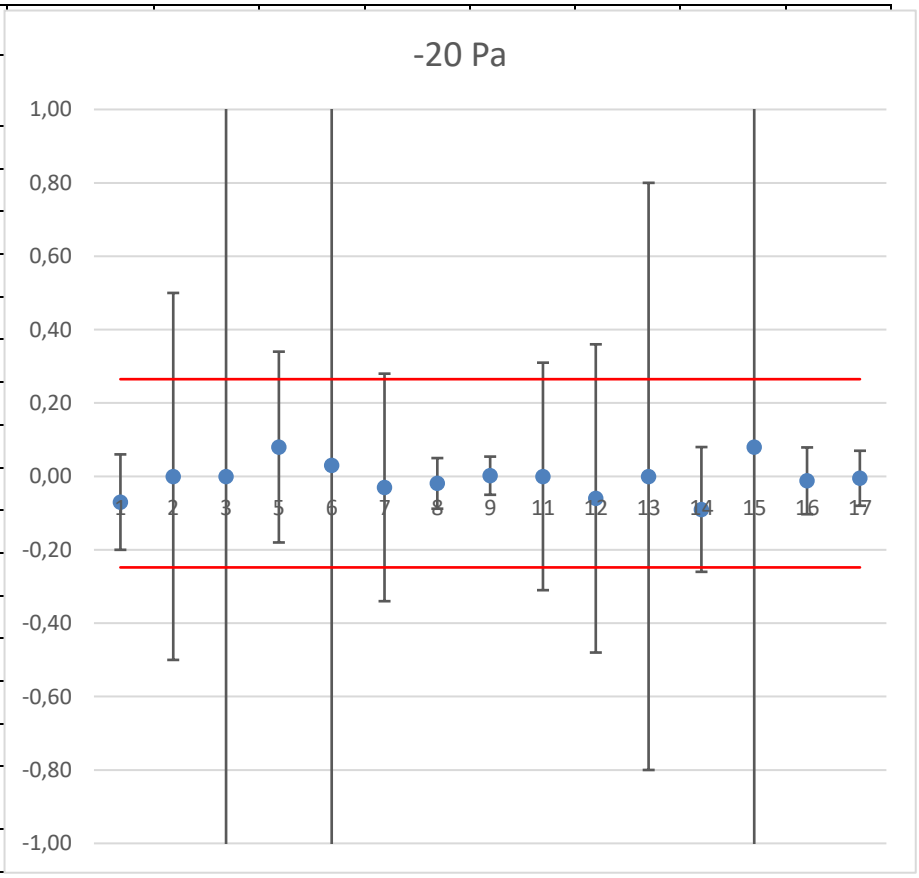


Table 7 0 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	0,00	0,12	0,07
2	0,00	0,50	0,02
3	0,09	1,19	0,08
5	0,01	0,20	0,09
6	0,00	2,54	0,00
7	0,000	0,031	0,11
8	-0,013	0,035	0,03
9	0,001	0,050	0,11
11	0,0	0,31	0,03
12	0,01	0,15	0,12
13	0,01	0,80	0,02
14	-0,09	0,17	0,42
15	0,04	1,2	0,04
16	-0,004	0,071	0,05
17	-0,007	0,055	0,03
	Ref error	Ref Uncer-tainty	
	-0,010	0,084	

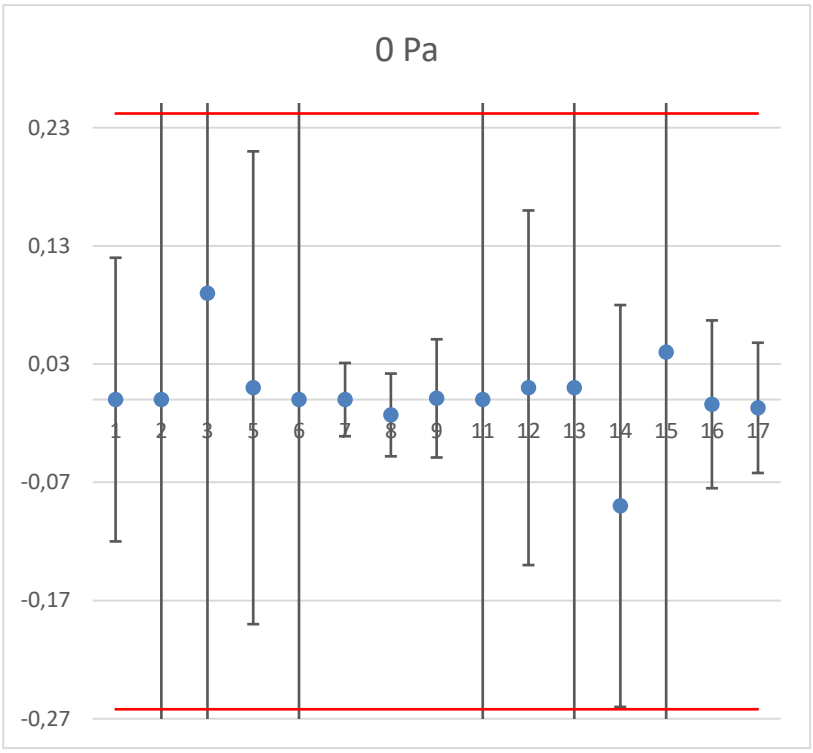


Table 8 20 Pa, Results and diagram

Identification	Error	Uncer-tainty	En value
1	0,06	0,13	0,55
2	0,01	0,50	0,07
3	0,19	1,19	0,18
5	-0,02	0,27	0,03
6	-0,04	2,54	0,00
7	0,04	0,31	0,21
8	-0,014	0,066	0,12
9	-0,030	0,051	0,02
11	0,0	0,31	0,09
12	0,04	0,42	0,16
13	-0,02	0,80	0,01
14	0,05	0,17	0,40
15	0,07	1,8	0,05
16	-0,048	0,089	0,16
17	0,005	0,080	0,27
	Ref er-ror	Ref Uncer-tainty	
	-0,0275	0,0905	

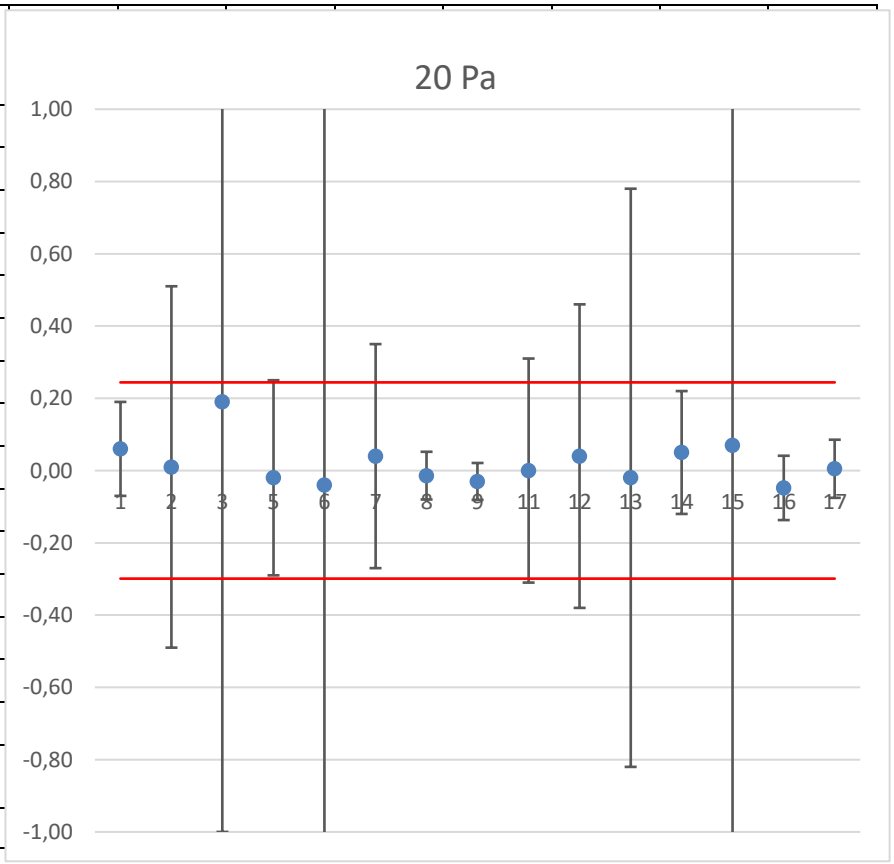


Table 9 50 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	0,07	0,13	0,57
2	0,02	0,50	0,08
3	0,28	1,19	0,25
5	0,05	0,26	0,25
6	-0,11	2,75	0,03
7	0,05	0,33	0,20
8	-0,012	0,072	0,07
9	0,004	0,054	0,23
11	0,0	0,31	0,06
12	0,04	0,42	0,14
13	-0,07	0,80	0,06
14	0,05	0,20	0,32
15	0,05	1,5	0,05
16	-0,08	0,12	0,40
17	0,007	0,096	0,21
	Ref error	Ref Uncer-tainty	
	-0,020	0,090	

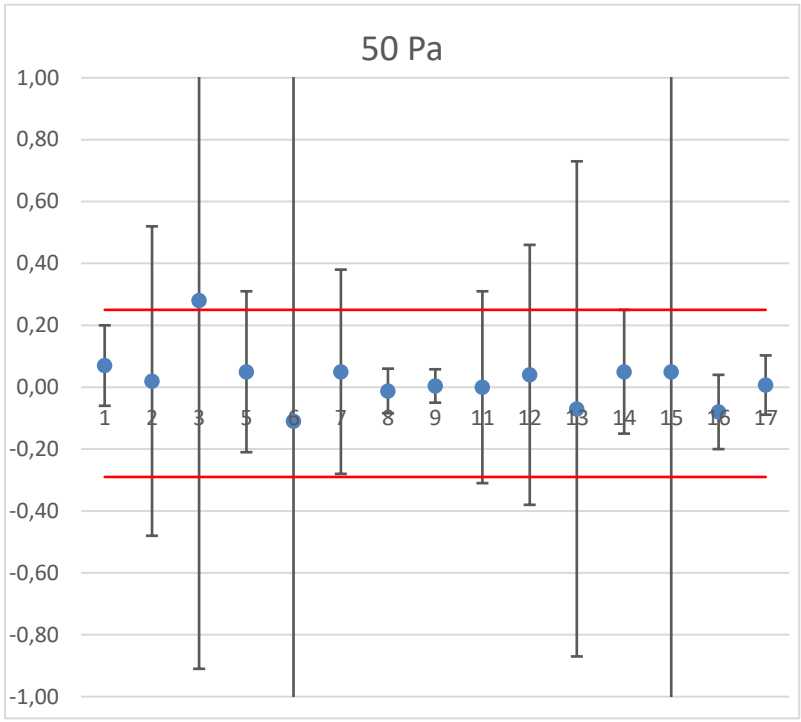


Table 10 100 Pa, Results and diagram

Identification	Error	Uncer-tainty	En value
1	0,10	0,14	0,70
2	-0,03	0,50	0,03
3	0,34	1,19	0,30
5	0,09	0,26	0,39
6	-0,25	3,10	0,08
7	0,06	0,35	0,21
8	-0,013	0,074	0,03
9	-0,003	0,057	0,13
11	0,0	0,31	0,05
12	0,01	0,42	0,06
13	-0,12	0,80	0,13
14	0,05	0,25	0,25
15	0,06	1,8	0,04
16	-0,030	0,085	0,10
17	0,002	0,082	0,16
	Ref er-ror	Ref Uncer-tainty	
	-0,017	0,091	

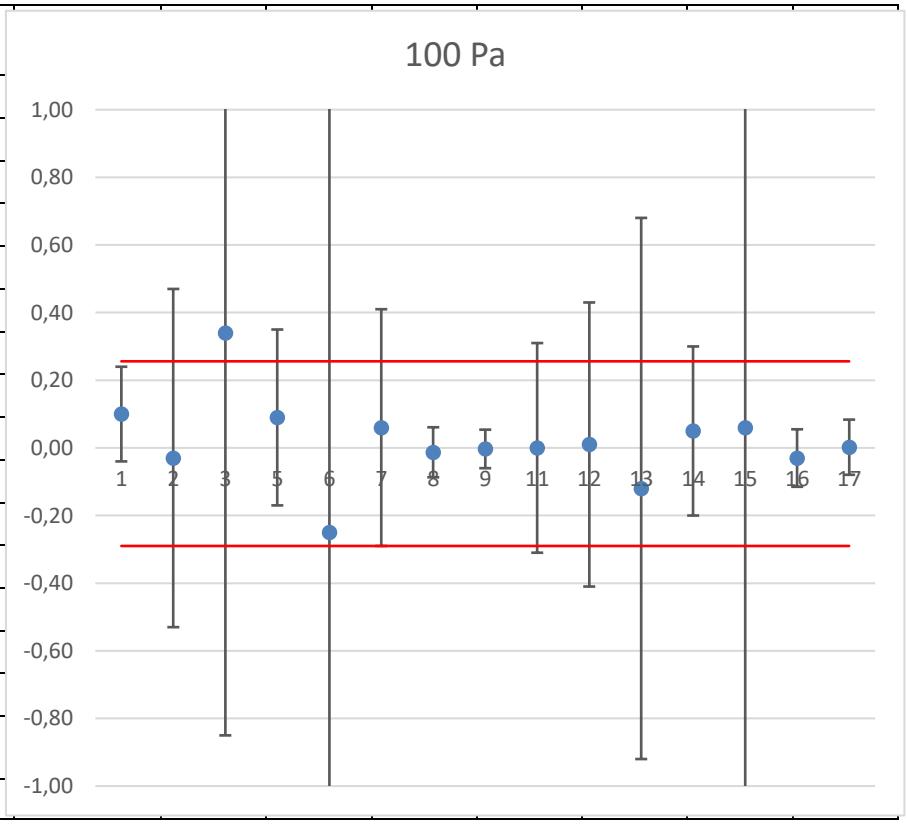


Table 11 150 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	0,15	0,14	0,94
2	-0,05	0,50	0,07
3	0,32	1,19	0,28
5	0,10	0,29	0,36
6	-0,44	3,45	0,12
7	-0,09	0,38	0,20
8	-0,009	0,063	0,03
9	-0,001	0,061	0,09
11	0,0	0,31	0,04
12	0,02	0,42	0,07
13	-0,15	0,80	0,17
14	0,08	0,30	0,29
15	0,74	4,7	0,16
16	-0,028	0,089	0,12
17	0,002	0,069	0,11
	Ref error	Ref Uncertainty	
	-0,012	0,101	

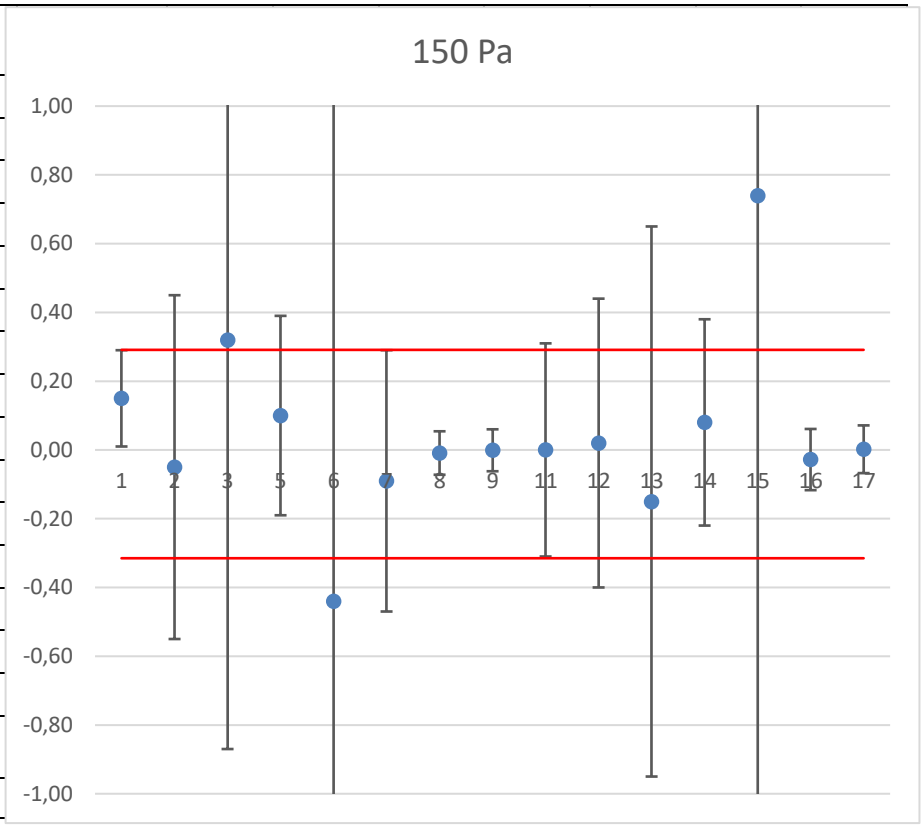


Table 12 200 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	0,13	0,15	0,80
2	-0,07	0,50	0,11
3	0,58	1,19	0,50
5	0,11	0,32	0,37
6	-0,62	3,80	0,16
7	-0,09	0,40	0,19
8	-0,011	0,067	0,01
9	-0,007	0,065	0,04
11	0,1	0,41	0,27
12	0,02	0,42	0,07
13	-0,16	0,80	0,18
14	0,06	0,35	0,20
15	0,23	5,0	0,05
16	0,004	0,095	0,12
17	-0,011	0,077	0,01
	Ref error	Ref Uncertainty	
	-0,012	0,096	

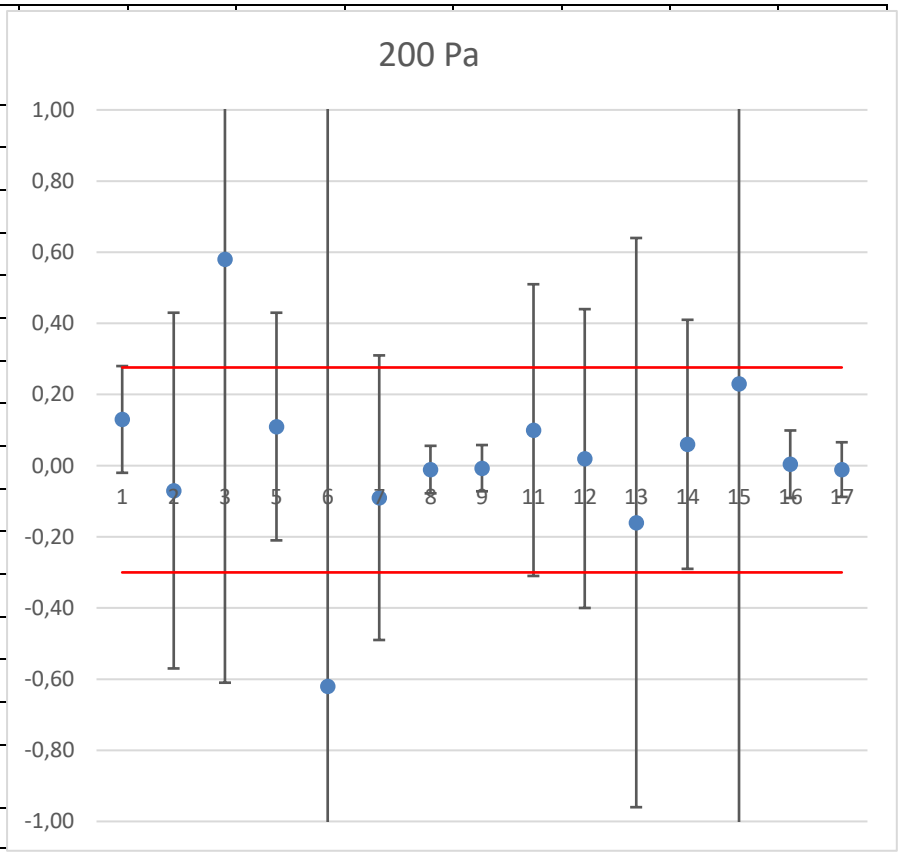


Table 13 250 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1	0,14	0,16	0,81
2	-0,09	0,50	0,14
3	0,50	1,21	0,43
5	0,14	0,33	0,46
6	-0,78	4,15	0,18
7	-0,09	0,43	0,16
8	-0,008	0,058	0,09
9	-0,002	0,069	0,13
11	0,4	0,51	0,80
12	0,03	0,42	0,11
13	-0,17	0,80	0,19
14	0,02	0,40	0,10
15	0,90	5,2	0,18
16	-0,01	0,10	0,07
17	0,004	0,081	0,17
	Ref error	Ref Uncertainty	
	-0,020	0,115	

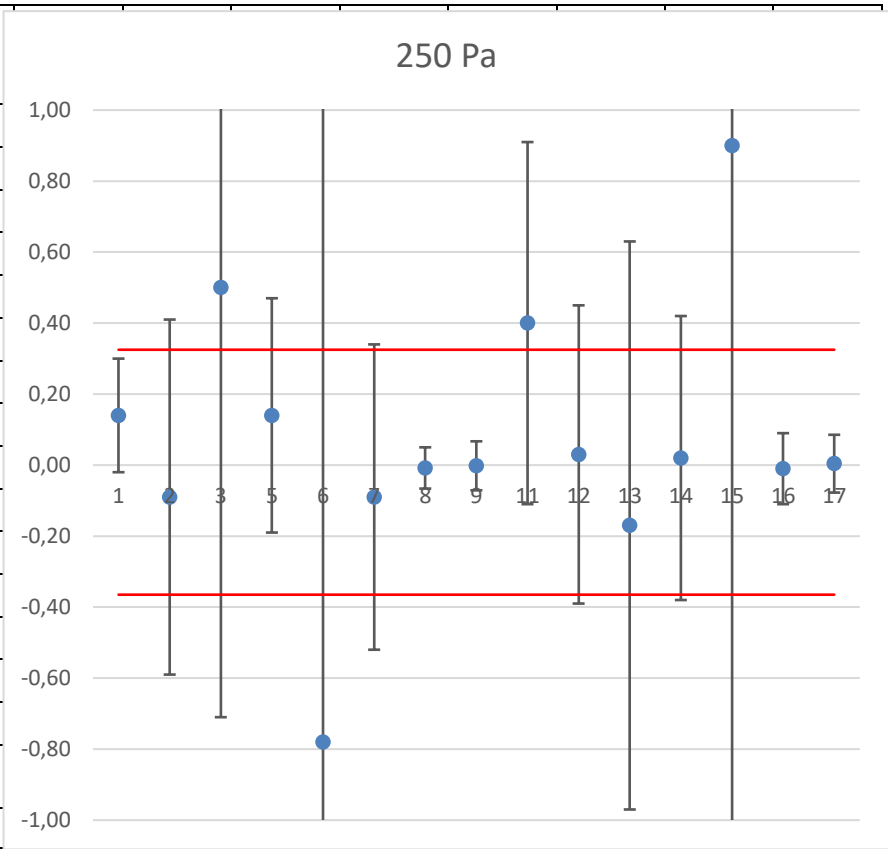


Table 14 -2500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	0,60	7,5	0,09
4	-0,4	0,47	0,53
5	0,49	1,35	0,43
7	0,21	0,83	0,36
8	0,00	0,113	0,34
9	-0,21	0,62	0,15
10	-0,30	0,67	0,26
11	-2,9	5,1	0,55
12	-0,45	0,58	0,53
14	-1,0	4,0	0,22
15	1,9	19	0,11
16	-0,20	0,40	0,19
17	-0,07	0,142	0,12
	Ref error	Ref Uncertainty	
	-0,108	0,292	

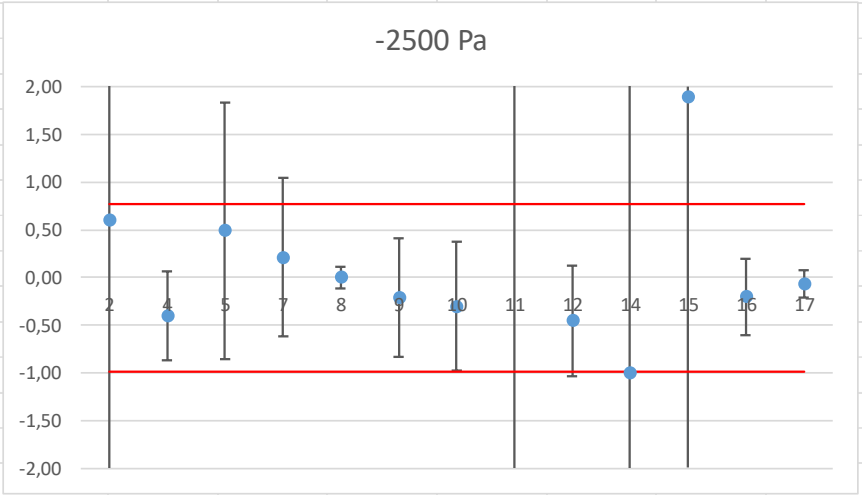


Table 15 -2000 Pa, Results and diagram

Identification	Error	Uncertainty	En value
1			0,41
2	0,4	7,5	0,07
4	-0,3	0,42	0,37
5	-0,69	1,30	0,43
7	0,20	0,71	0,41
8	-0,01	0,106	0,35
9	-0,24	0,52	0,21
10	-0,43	0,63	0,46
11	-2,7	4,1	0,63
12	-0,43	0,57	0,50
14	-1,0	3,6	0,25
15	1,20	16	0,08
16	-0,20	0,32	0,20
17	-0,15	0,112	0,12
	Ref error	Ref Uncertainty	
	-0,115	0,278	

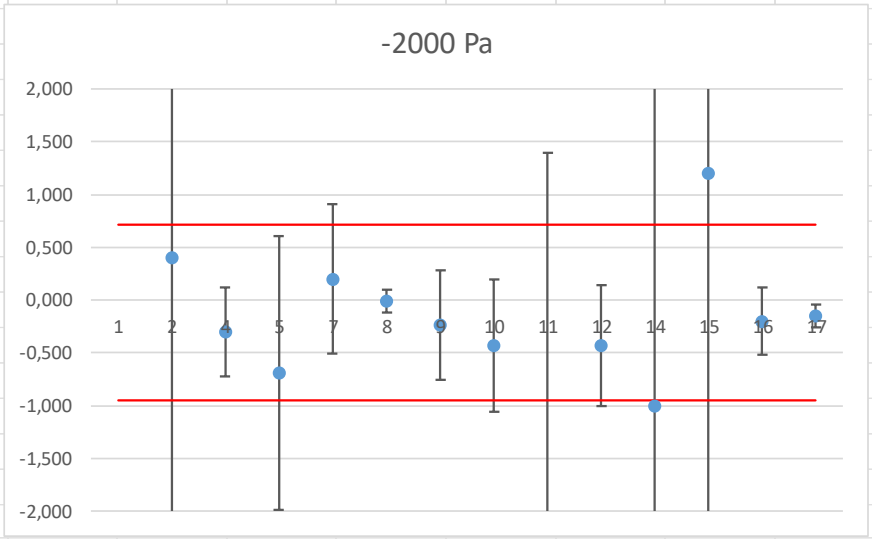


Table 16 -1500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	0,2	7,5	0,04
4	-0,2	0,37	0,16
5	-0,66	1,25	0,42
7	0,14	0,58	0,45
8	-0,04	0,104	0,41
9	-0,24	0,45	0,21
10	-0,25	0,60	0,18
11	-2,0	3,1	0,60
12	-0,35	0,56	0,36
14	-1,0	3,2	0,27
15	0,90	13	0,08
16	-0,21	0,26	0,23
17	-0,13	0,098	0,02
	Ref error	Ref Uncertainty	
	-0,134	0,204	

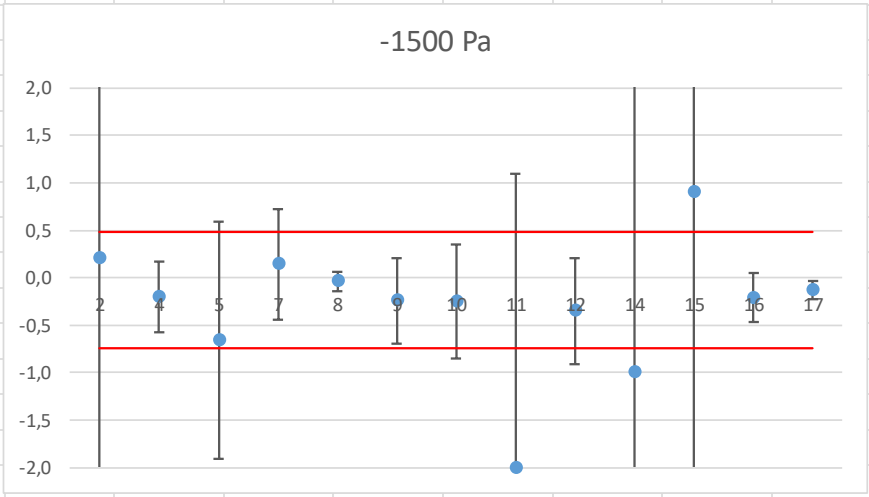


Table 17 -1000 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	0,1	7,5	0,03
3	-2,5	1,5	1,59
4	-0,1	0,34	0,01
5	-0,65	1,20	0,46
7	0,04	0,46	0,27
8	-0,04	0,084	0,29
9	-0,13	0,27	0,11
10	-0,29	0,56	0,33
11	-1,3	2,1	0,57
12	-0,28	0,55	0,32
14	0,0	1,2	0,08
15	0,80	10	0,09
16	-0,11	0,19	0,06
17	-0,09	0,092	0,02
	Ref error	Ref Uncertainty	
	-0,095	0,169	

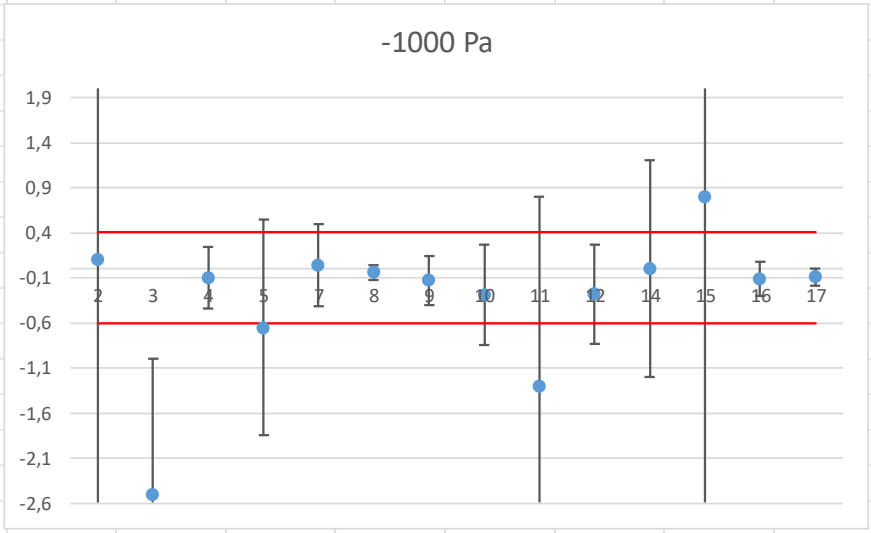


Table 18 -500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	0,0	7,5	0,01
3	-1,2	1,3	0,88
4	0,0	0,31	0,15
5	-0,42	0,35	1,00
7	-0,15	0,36	0,27
8	-0,06	0,073	0,08
9	-0,10	0,130	0,29
10	-0,33	0,51	0,54
11	-0,6	1,1	0,50
12	-0,18	0,54	0,24
14	-0,01	0,65	0,06
15	0,60	7	0,09
16	-0,11	0,14	0,33
17	-0,09	0,087	0,28
	Ref error	Ref Uncertainty	
	-0,049	0,120	

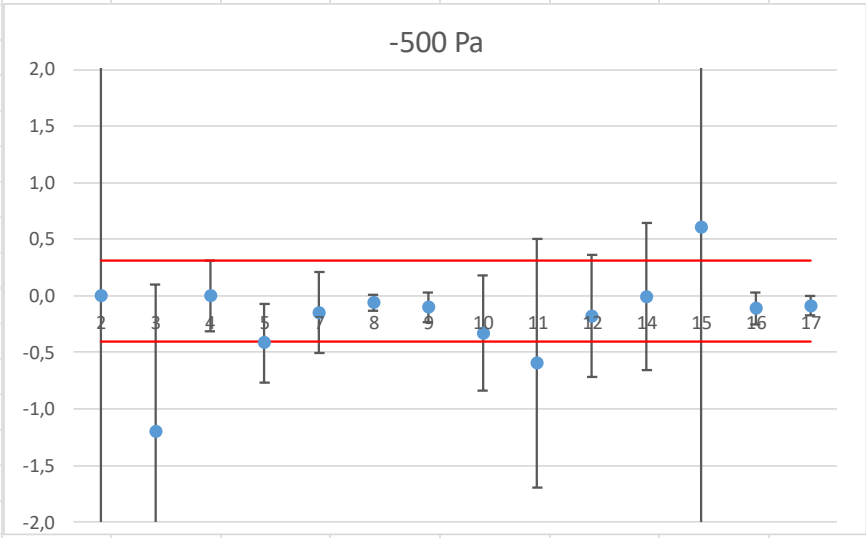


Table 19 0 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	0,0	7,5	0,00
3	0,1	1,2	0,09
4	0,0	0,28	0,01
5	0,00	0,20	0,01
7	0,00	0,11	0,02
8	-0,01	0,063	0,07
9	0,011	0,050	0,14
10	-0,03	0,42	0,06
11	0,0	0,32	0,01
12	0,00	0,20	0,01
14	0,00	0,16	0,02
15	0,10	4	0,03
16	0,005	0,071	0,07
17	-0,01	0,078	0,06
	Ref error	Ref Uncertainty	
	-0,003	0,084	

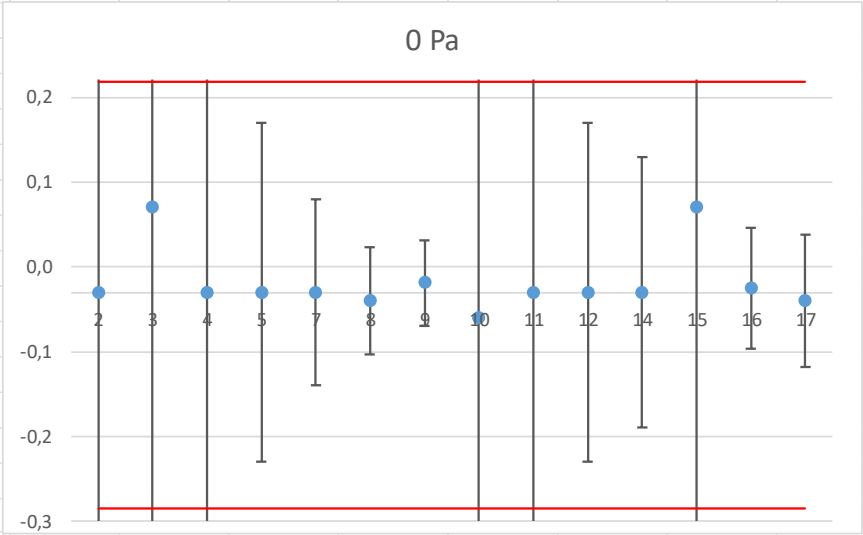


Table 20 500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	-0,1	7,5	0,01
3	1,1	1,3	0,86
4	0,1	0,31	0,36
5	0,04	0,35	0,16
7	0,05	0,36	0,19
8	0,03	0,090	0,31
9	0,04	0,16	0,29
10	-0,08	0,52	0,11
11	0,5	1,1	0,47
12	-0,05	0,54	0,05
14	0,05	0,65	0,11
15	-0,30	7	0,04
16	0,01	0,13	0,17
17	-0,22	0,087	1,22
	Ref error	Ref Uncertainty	
	-0,022	0,138	

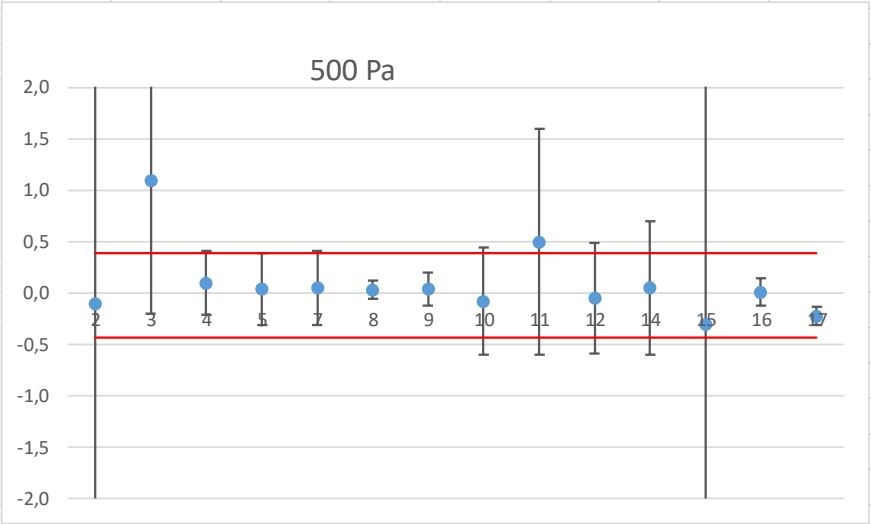


Table 21 1000 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	-0,1	7,5	0,01
3	2,2	1,5	1,46
4	0,1	0,34	0,29
5	-0,36	1,20	0,29
7	-0,17	0,46	0,32
8	0,04	0,097	0,24
9	0,09	0,28	0,30
10	-0,16	0,58	0,24
11	1,2	2,1	0,57
12	0,03	0,55	0,07
14	0,0	1,2	0,01
15	0,60	10	0,06
16	0,110	0,190	0,45
17	0,03	0,112	0,19
	Ref error	Ref Uncertainty	
	-0,012	0,194	

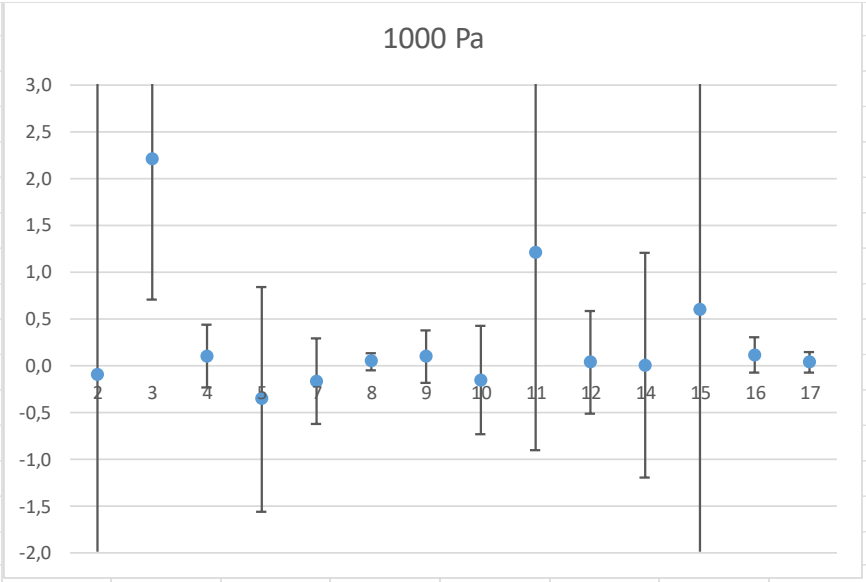


Table 22 1500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	-0,2	7,5	0,03
4	0,2	0,37	0,49
5	-0,80	1,25	0,62
7	-0,24	0,58	0,37
8	0,00	0,087	0,04
9	0,07	0,40	0,17
10	-0,14	0,61	0,20
11	2,0	3,1	0,65
13			0,04
14	1,0	3,2	0,31
15	0,00	13	0,00
16	0,10	0,26	0,32
17	0,01	0,098	0,08
	Ref error	Ref Uncertainty	
	-0,009	0,217	

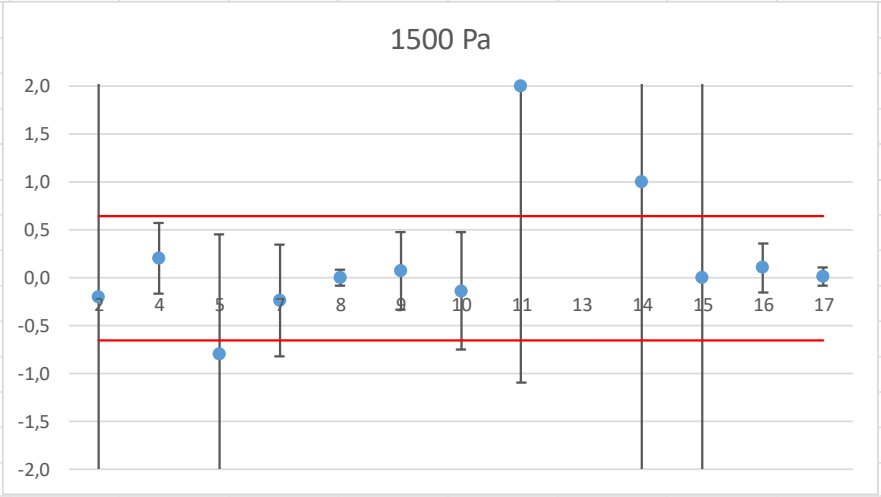


Table 23 2000 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	-0,3	7,5	0,04
4	0,30	0,42	0,60
5	-0,29	1,30	0,21
7	-0,30	0,71	0,37
8	-0,04	0,098	0,09
9	0,06	0,52	0,12
10	-0,13	0,66	0,16
11	2,6	4,1	0,64
12	0,05	0,57	0,10
14	0,9	3,6	0,25
15	-1,10	16	0,07
16	0,11	0,32	0,27
17	0,04	0,130	0,15
	Ref error	Ref Uncertainty	
	-0,012	0,311	

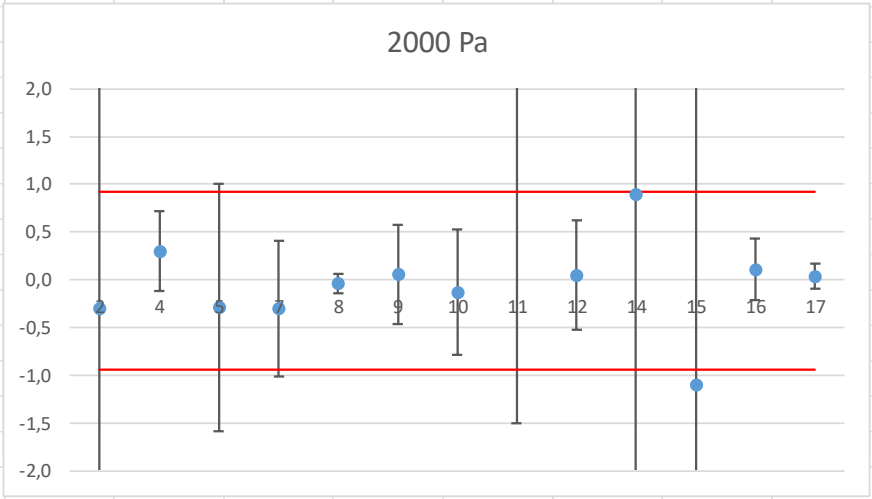
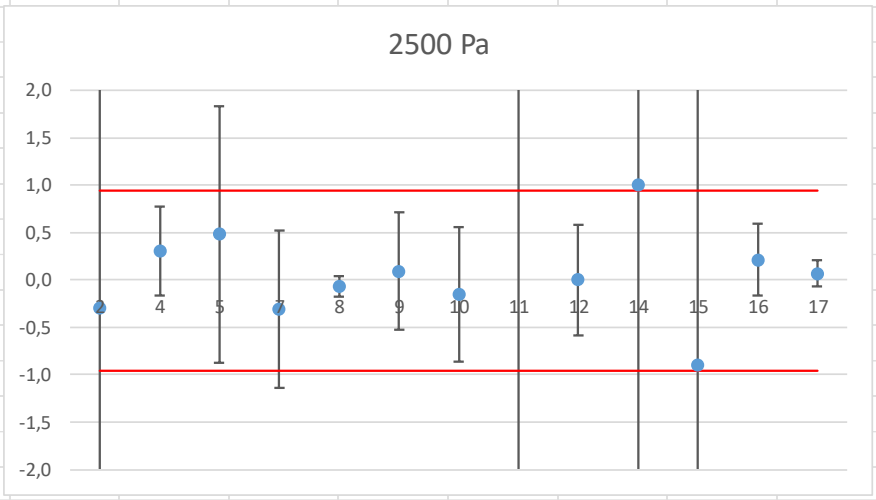


Table 24 2500 Pa, Results and diagram

Identification	Error	Uncertainty	En value
2	-0,3	7,5	0,04
4	0,3	0,47	0,54
5	0,48	1,35	0,35
7	-0,31	0,83	0,34
8	-0,07	0,110	0,19
9	0,09	0,62	0,14
10	-0,15	0,71	0,18
11	3,0	5,1	0,59
12	0,00	0,58	0,01
14	1,0	4,0	0,25
15	-0,90	19	0,05
16	0,21	0,38	0,44
17	0,07	0,142	0,22
	Ref error	Ref Uncertainty	
	-0,008	0,318	



Comments on the calibration certificates

-- not a part of the intercomparison

Several laboratories report all repetitions (up to 10 repetitions) and the mean result.

The laboratories report measurement errors, deviation or correction.

Some laboratories declare that they have calibrated in vertical position.

Some laboratories indicate temperature and local gravity.

One laboratory gives a diagram in relation to correction and uncertainty.

Some laboratories specify the environmental conditions like atmospheric pressure, temperature and humidity.

Some laboratories are clearly identifying the reference equipment used.

Several laboratories relate the results to the specification of the calibrated equipment.

Most of the laboratories are referring to EA publication EA-4/02 on uncertainty.

One laboratory indicates their decision rule in relation to calibration values.

One laboratory indicates values better than the approved CMC value to apply for a better CMC value at the accreditation body.

Some laboratories indicate the relation to the specification of the instrument.

Additions and changes to the DRAFT report and final report revision 1

Redactional changes and several changes of input values from participants but does not change results significant.

There was still a misinterpretation of the result in the final report from one participant that is now corrected but does not change En values significantly.

Final conclusions

In this inter comparison most of the participants could demonstrate a capacity to calibrate and give relevant values in relationship to their uncertainties.

The uncertainty claims vary between participants that can be seen in the tables above.

The results are as follows: 364 calibration points where 5 En values are above 1

Acknowledgement

We gratefully thank the member of the advisory board and expert in pressure calibrations Aykurt Altintas, Force Denmark

We gratefully thank Wilmer and Arvid Manfredsson thar checked many input results and made basic calibrations and validation of calculations

Annex 1 ILC pressure 2022:1

Published on https://smquality.se/

Annex 2 *D*escription of the intercomparison/ILC

Published on https://smquality.se/

Annex 3 Reporting forms

Pressure gauge no. 1

Obligatory calibration points	Applied reference pressure	Measured gauge pressure	Calculated indication error	Stated measurement uncertainty
Pa	Pa	Pa	Pa	Pa
-250			0	
-200			0	
-150			0	
-100			0	
-50			0	
-20			0	
0			0	
20			0	
50			0	
100			0	
150			0	
200			0	
250			0	

Pressure gauge no. 2

Obligatory calibration points	Applied reference pressure	Measured gauge pressure	Calculated indication error	Stated measurement uncertainty
Pa	Pa	Pa	Pa	Pa
-2500			0,00	
-2000			0,00	
-1500			0,00	
-1000			0,00	
-500			0,00	
0			0,00	
500			0,00	
1000			0,00	
1500			0,00	
2000			0,00	
2500			0,00	

References:

- ISO/IEC 17043:2023 Conformity assessment – General requirements for proficiency testing
- ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories
- ISO 13528:2022 Statistical methods for use in proficiency testing by interlaboratory comparison
- Evaluation of measurement data – Guide to the expression of uncertainty in measurement, GUM (JCGM 100:2008)
- EA-4/02 M:2013 Evaluation of Uncertainty of Measurement in Calibration
- International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)