Swedish Metrology and Quality AB

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Proficiency testing
ISO/IEC 17043

ilac-MRA

To participants

Report on an interlaboratory comparison (ILC) of the calibration in the pressure area

The bag carrying 2 equipment for calibration.

Weight 2kg

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Calculations

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Content

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 2021:1 intercomparison as well as the choice of measuring points that are defined to be included in the evaluation of the results.

The advisory group consist of Aykurt Altintas, Force Technology Denmark Peter Lau MNE consult and Håkan Källgren Swedish Metrology and Quality.

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.

List of objects

The following instruments are included:

Compound pressure -0,95 to +1 bar

Gauge pressure 0 to 30 bar

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	**Proposed calibra-tion week**
RISE, reference laboratory	24
Nordtec Instrument AB, Sweden	25
QS-Grimm GmbH, Germany	26
Calpro Hagels/Theußing GmbH & Co. KG, Germany	27
Butler Technologies, Ireland	28
MS2 Egineering und Anlagenbau GmbH,Germany	29
Inspecta Tarkastus Ltd, Finland	31
Ircal Oy, Finland	32
SGS Fimko Oy, Finland	33
Finnish defense forces, Finland	34 -35
Karolinska Universitetssjukhuset Huddinge, Sweden	38
RISE, reference laboratory	39
Baugrund Institut Knirim OOD-Soil testing laboratory, Bulgaria	41
National Metrology Institute of Ethiopia (NMIE)	43
RISE, reference laboratory, additional control	44

There were some delays that ended by the last calibration at week 50

A majority performed a calibration on all equipment, others only on one object or a part of the instrument for compound pressure. During the exercise all together 15 calibrations were performed.

Most of the participants have an accreditation by SWEDAC, DANAK, FINAS, DAkkS and BAS Bulgaria

One laboratory as 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 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.

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, but no one used this possibility.

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

The participant should calibrate according to the following points on the objects:

Gauge pressure	Range: ± 1 bar, Calibration points: -0,95; -0,5; 0; 0,3; 0,5; 1 bar
Gauge pressure	Range: 0 – 30 bar Calibration points: 0; 6; 12; 18; 24; 30 bar

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 17043:2010 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 found error at all measurement points. It is simply the difference between the displayed pressure on the pressure gauge and the adjusted reference pressure read from a calibrated 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 E_n – criteria. For each measurement point it is the distance of respective laboratory result to the corresponding 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}: Provided inter-comparison reference value.

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

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

Inter-comparison reference value

The reference laboratory provided the same uncertainty U_{reflab} in the beginning and at the end of the exercise. It was also independent of the 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.

$$U_{ref} = U_{reflab} + abs(x_{R2} - x_{R1})$$

This drift was very small and always within the uncertainty of the reference laboratory.

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 (105102–155035-K01 and 105102–155035-K02 before and 105102-155035-K03 and 105102-155035-K04 after the ILC. 2 supporting checks of stability were done as well.

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 comparison for the different equipment that were calibrated.

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 “displayed instrument values” are listed in the following tables. This should allow the participants to compare the tabled data in this report with their own documentation. Whereas in the excel-protocols (annex 3) results were listed in both directions (increasing and decreasing pressure) the report tables only contain one figure for each pressure level. It is the average value for the used references, the displayed indications, and the average error in upwards and downwards direction. Few participants had different uncertainties for increasing and decreasing pressure values. In these cases, even here, the tables contain an average uncertainty.

It was the ambition of the organizer to directly incorporate the various excel-protocols into the colocation 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 as intended.

The participation numbering P1 to P12 is arbitrary and not in time order of calibration. This identity is kept in the whole report. Empty lines therefore indicate that for those points no calibration values were provided. All tables start and end with the calibration results from the reference laboratory named R1 and R2. Their average defines the inter-comparison reference value x_{ref} given in the line below denoted as R1&R2 together with the estimated uncertainty U_{ref}. In each table these two values are used for calculating the participants En-values displayed in the last column.

In a few cases a participant could not reach a stipulated pressure point, but this was accepted as good enough for the comparison. Two laboratories were not able to achieve the upper pressure levels, but their results for the lower ones are accepted. Two other laboratories delivered the higher-pressure values but mentioned in their certificates that these are not part of their accreditation and stated a higher uncertainty.

The low-pressure instrument was an absolute pressure gauge. At the first calibration at Rise its zero point was set and in the following calibration the instrument was treated as a gage pressure device. Both instruments were new and not in use before the inter-comparison but one of them was manipulated for deviations from instrument specification. Some laboratories explicitly declared the instrument passed or failed for every measured pressure point.

Sensor 1 – negative gauge pressure

Table 1: Zero point - R1 and R2 are data from reference laboratory, R1&R2 is their mean.

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	0,000	0,000	0,000	0,10	
P1	0,000	0,000	0,000	0,12	**0,00**
P2	0,000	0,000	0,000	2,6	**0,00**
P3	0,000	0,050	0,050	0,55	**0,09**
P4					
P5	0,000	-0,300	-0,300	13	**-0,02**
P6	0,050	0,000	-0,050	0,33	**-0,15**
P7	0,000	0,000	0,000	0,30	**0,00**
P8	0,000	0,000	0,000	0,80	**0,00**
P9	0,000	0,100	-0,100	0,50	**-0,20**
P10					
P11	-0,003	0,050	0,052	0,10	**0,37**
P12					
R2	0,000	0,000	0,000	0,10	
R1&R2			**0,000**	**0,100**	

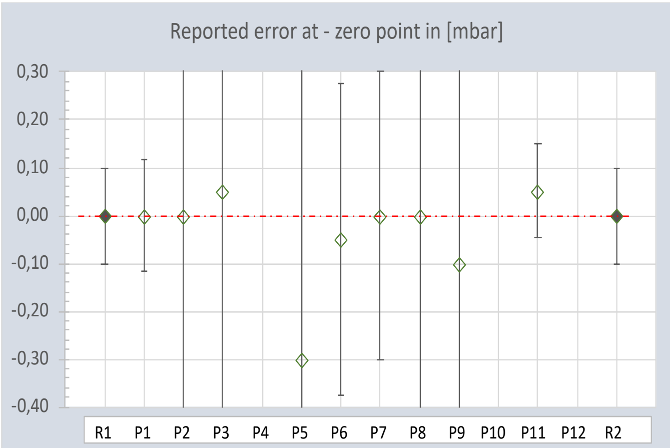

Figure 1: Measured deviation from zero pressure with reported uncertainties. Red line is the comparison reference value

Table 2: Measurement point 2 - participant declared error at -0,5 bar with reported uncertainties.

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	-500,73	-500,60	0,130	0,10	
P1	-500,33	-500,20	0,126	0,13	**0,18**
P2	-500,15	-500,15	0,000	2,6	**-0,04**
P3	-500,30	-499,95	0,250	0,55	**0,28**
P4					
P5	-500,00	-500,20	-0,200	13,0	**-0,02**
P6	-500,03	-499,90	0,125	0,49	**0,06**
P7	-499,50	-499,55	-0,050	0,30	**-0,43**
P8	-499,90	-500,00	-0,100	0,80	**-0,24**
P9	-500,00	-499,70	-0,300	0,50	**-0,76**
P10					
P11	-500,00	-499,85	0,152	0,10	**0,35**
P12					
R2	-500,73	-500,68	0,055	0,10	
R1&R2			**0,092**	**0,137**	

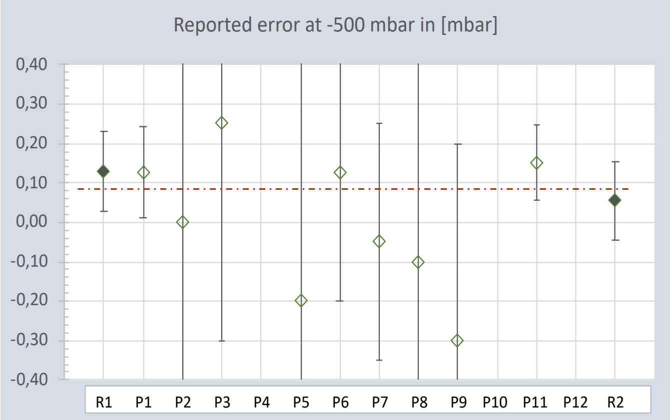

Figure 2: Reported error (mean of increasing / decreasing) from a negative pressure of -0,5 bar.

Table 3: Measurement point 3 - participant declared error at -0,95 bar with reported uncertainties.

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	-951,22	-951,30	-0,080	0,10	
P1	-950,64	-950,60	0,037	0,15	**0,64**
P2	-883,20	-883,50	-0,250	2,60	**-0,07**
P3	-950,30	-950,00	0,200	0,55	**0,50**
P4					
P5	-950,00	-950,40	-0,400	13,0	**-0,02**
P6	-950,00	-950,05	-0,025	0,50	**0,11**
P7	-949,50	-949,30	0,050	0,30	**0,41**
P8	-949,90	-950,10	-0,200	0,90	**-0,13**
P9	-949,98	-949,90	-0,100	0,50	**-0,04**
P10					
P11	-950,01	-950,10	-0,098	0,12	**-0,12**
P12					
R2	-951,22	-951,30	-0,080	0,10	
R1&R2			-0,080	0,100	

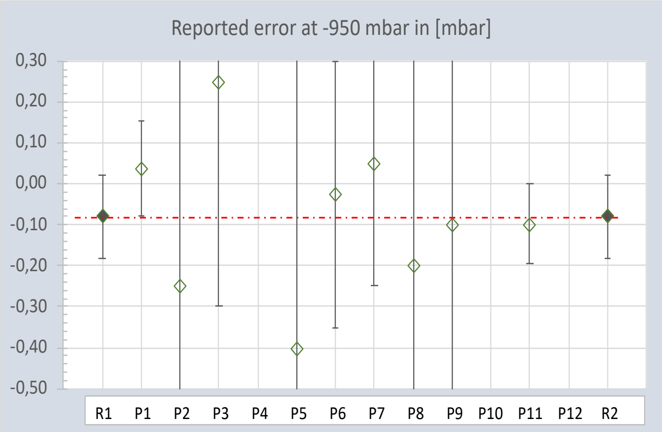

Figure 3: Recorded average error (increasing / decreasing) from a negative pressure of -0,95 bar.

Comments: Three participants were not able to take part in this part of the inter-comparison (at vacuum pressure). The uncertainty data (fourth column) is displayed in the diagram by symmetrical stables.

Sensor 1 – low pressure

Table 4: New zero-point control

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	0,000	0,000	0,000	0,10	
P1	0,000	0,000	0,000	0,12	**0,00**
P2	0,000	0,000	0,000	3,00	**0,00**
P3	0,000	0,050	0,050	0,55	**0,09**
P4					
P5	0,000	-0,300	-0,300	13,0	**-0,02**
P6	0,025	0,000	-0,025	0,33	**-0,07**
P7	0,000	-0,100	-0,100	0,30	**-0,32**
P8	0,000	0,000	0,000	0,80	**0,00**
P9	0,000	0,100	-0,100	0,50	**-0,20**
P10	-0,600	0,000	0,000	1,40	**0,00**
P11	-0,007	0,000	0,006	0,14	**0,03**
P12					
R2	0,000	0,000	0,000	0,10	
R1&R2			**0,000**	**0,10**	

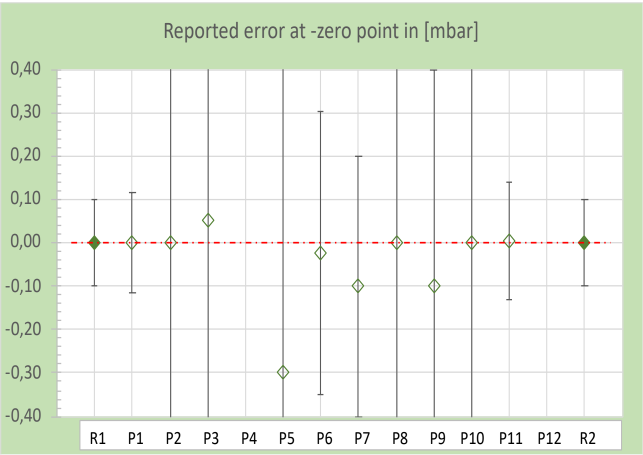

Figure 4: Reported deviations from a new zero point after removing the negative pressure

Table 5: Measurement point 2 at 0,3 bar

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	300,35	300,43	0,075	0,10	
P1	300,19	300,30	0,110	0,12	**0,29**
P2	299,89	300,00	0,110	3,00	**0,02**
P3	300,00	300,15	0,150	0,55	**0,16**
P4					
P5	300,00	299,80	-0,200	13,0	**-0,02**
P6	299,98	300,10	0,125	0,49	**0,12**
P7	300,30	301,15	-0,100	0,30	**-0,51**
P8	300,00	300,00	0,000	0,80	**-0,08**
P9	300,00	300,20	-0,200	0,50	**-0,51**
P10	299,58	300,00	-0,200	1,40	**-0,19**
P11	299,99	300,10	0,105	0,14	**0,24**
P12					
R2	300,35	300,40	0,050	0,10	
R1&R2			**0,062**	**0,112**	

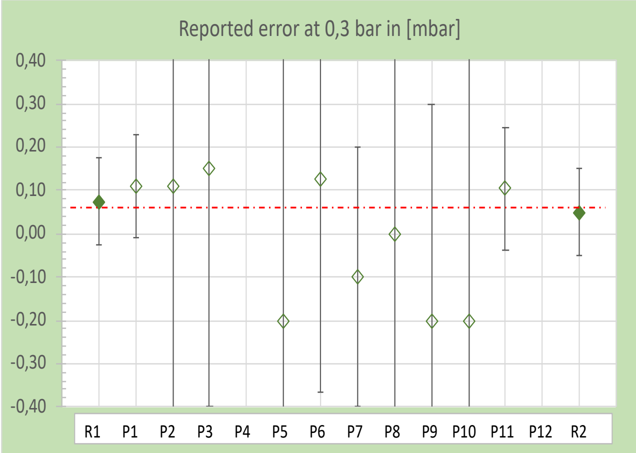

Figure 5: Reported error at 0,3 bar. All values are the average from increasing and decreasing pressure.

Table 6: Measurement point 3 at 0,5 bar

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	500,69	500,90	0,210	0,10	
P1	500,33	500,50	0,174	0,12	**0,07**
P2	499,91	500,10	0,190	3,00	**0,01**
P3	499,70	500,05	0,350	0,55	**0,33**
P4					
P5	500,10	499,90	-0,200	13,0	**-0,03**
P6	500,00	500,15	0,150	0,49	**-0,02**
P7	499,80	500,30	-0,200	0,30	**-1,07**
P8	499,90	500,05	0,150	1,20	**-0,01**
P9	500,00	500,20	-0,200	0,50	**-0,69**
P10	499,40	500,00	0,000	1,40	**-0,11**
P11	499,99	500,20	0,208	0,15	**0,23**
P12					
R2	500,69	500,80	0,110	0,10	
R1&R2			**0,160**	**0,15**	

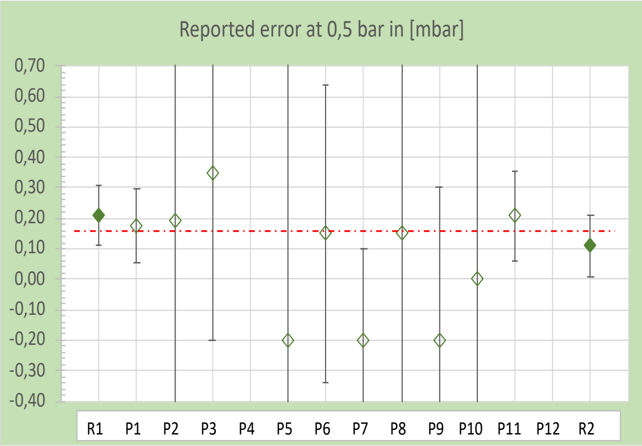

Figure 6: Reported average error at 0,5 bar around the red reference line with belonging uncertainty staples. Comment: Due to a high hysteresis effect for participant P7 at 0,3 and 0,5 bar in table 5 and 6 only the error at increasing pressure is given for P7, not the average with the decreasing value as for all other participants.

Table 7: Measurement point 4 at 1 bar

Partici-pant	Reference pressure [mbar]	Displayed value [mbar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	1000,80	1001,00	0,200	0,10	
P1	1000,67	1000,70	0,030	0,14	**-0,58**
P2	999,80	999,95	0,155	3,00	**0,00**
P3	999,40	999,95	0,550	0,55	**0,70**
P4					
P5	1000,10	999,90	-0,200	13,0	**-0,03**
P6	1000,00	1000,23	0,225	0,50	**0,14**
P7	1000,10	999,70	-0,400	0,30	**-1,64**
P8	999,90	1000,00	0,100	1,20	**-0,04**
P9	1000,00	1000,15	-0,100	0,50	**-0,48**
P10	999,24	1000,00	0,200	1,60	**0,03**
P11	999,99	1000,20	0,172	0,17	**0,10**
P12					
R2	1000,80	1000,90	0,100	0,10	
R1&R2			**0,150**	**0,15**	

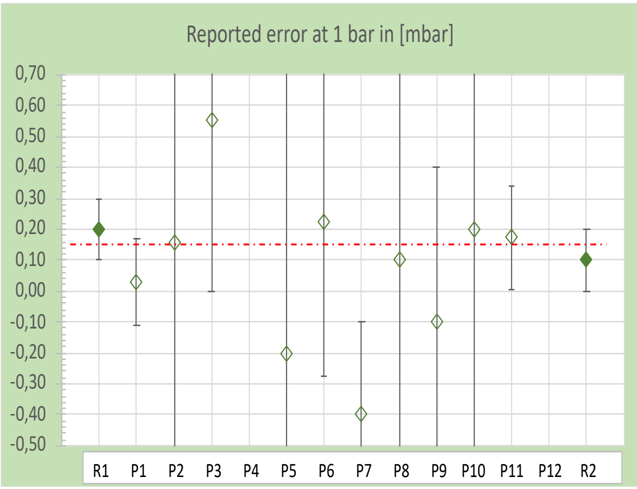

Figure 7: Reported average error at 1 bar around the red reference line (mean of R1 and R2 due to slight drift).

Comments: Two participants did not deliver calibration data to this part of the inter-comparison, therefor missing data in table 4 to 7 and corresponding diagrams.

Sensor 2 – 0 to 30 bar

Table 8: Measurement result 1 at zero point

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	0,000	0,000	0,00	1,0	
P1	0,000	0,000	0,00	1,15	**0,00**
P2	0,000	0,000	0,00	9,0	**0,00**
P3					
P4	0,000	0,001	1,30	12	**0,11**
P5	0,000	0,000	0,50	13	**0,04**
P6	0,0003	0,0015	1,25	5,85	**0,21**
P7	0,000	0,000	0,00	3,0	**0,00**
P8	0,000	0,000	0,00	1,0	**0,00**
P9					
P10	0,000	0,000	0,00	7,3	**0,00**
P11	0,000	0,000	-0,063	2,11	**-0,03**
P12	0,000	-0,029	-29,0	19	**-1,52**
R2	0,000	0,000	0,00	1,0	
R1&R2			**0,00**	**1,0**	

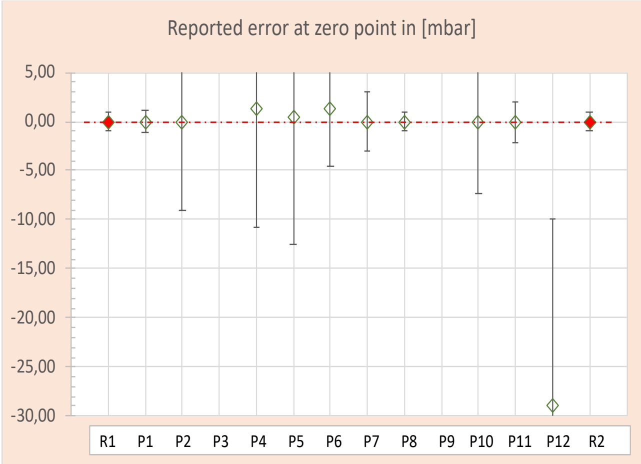

Figure 8: Reported average error at zero point – deviating results (especially P12) probably before zeroing the device.

Comment: Two participants P3 and P9 did not take part in this calibration of sensor 2.

Table 9: Measurement point 2 at 6 bars

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	6,006	6,016	9,800	1,0	
P1	6,004	6,015	10,908	1,25	**0,34**
P2	5,999	6,011	11,985	9,0	**0,19**
P3					
P4	6,000	6,013	12,80	13	**0,19**
P5	6,000	6,013	13,00	15	**0,18**
P6	6,000	6,013	13,00	7,74	**0,35**
P7	6,000	6,010	10,00	3,0	**-0,08**
P8	5,999	6,010	10,50	2,0	**0,10**
P9					
P10	5,987	6,000	12,825	7,5	**0,34**
P11	6,000	6,010	10,555	2,11	**0,12**
P12	6,000	6,022	22,00	19	**0,62**
R2	6,006	6,017	10,70	1,0	
R1&R2			**10,25**	**1,45**	

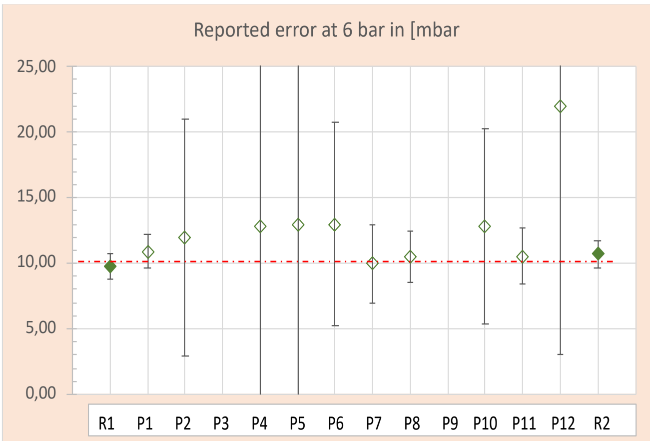

Figure 9: Reported average error and uncertainty at 6 bars. Drift in reference data +0,9 mbar

Table 10: Measurement point 3 at 12 bars

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	12,013	12,033	20,50	1,0	
P1	12,008	12,030	21,808	1,50	**0,38**
P2	11,997	12,021	23,95	9,0	**0,32**
P3					
P4	12,000	12,023	22,30	12,8	**0,10**
P5	12,002	12,025	22,50	15	**0,10**
P6	12,000	12,024	23,75	8,01	**0,34**
P7	11,999	12,016	17,00	3,0	**-1,19**
P8	11,999	12,019	20,00	3,0	**-0,30**
P9					
P10	11,975	12,000	25,311	7,5	**0,56**
P11	12,000	12,021	21,225	2,27	**0,08**
P12	12,000	12,007	36,00	19	**0,79**
R2	12,013	12,034	21,50	1,0	
R1&R2			**21,00**	**1,50**	

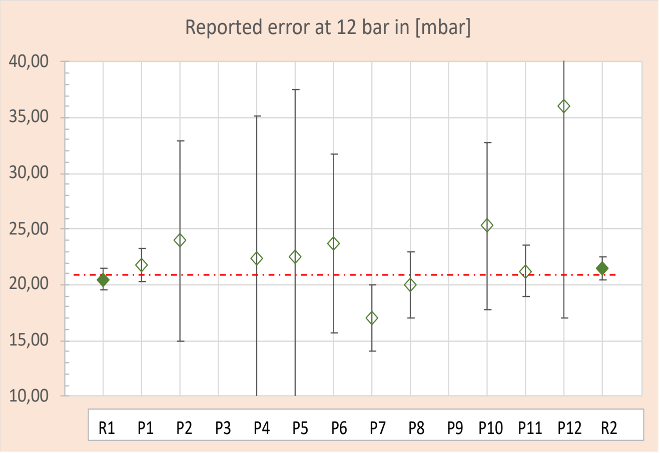

Figure 10: Reported average error and uncertainty at 12 bars. Drift in reference data +1 mbar

Table 11: Measurement point 4 at 18 bars

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	18,019	18,050	31,30	1,0	
P1	18,012	18,045	32,60	1,85	**0,36**
P2	17,997	18,033	35,95	9,0	**0,46**
P3					
P4	18,000	18,033	32,50	13	**0,06**
P5	18,003	18,039	35,50	15	**0,25**
P6	18,000	18,035	35,00	7,93	**0,40**
P7	17,999	18,031	32,00	3,0	**0,08**
P8	17,998	18,030	32,00	3,0	**0,08**
P9					
P10	17,960	18,000	39,929	8,7	**0,93**
P11	18,000	18,031	32,115	2,35	**0,13**
P12	18,000	18,013	42,00	19	**0,54**
R2	18,019	18,051	32,20	1,0	
R1&R2			**31,75**	**1,45**	

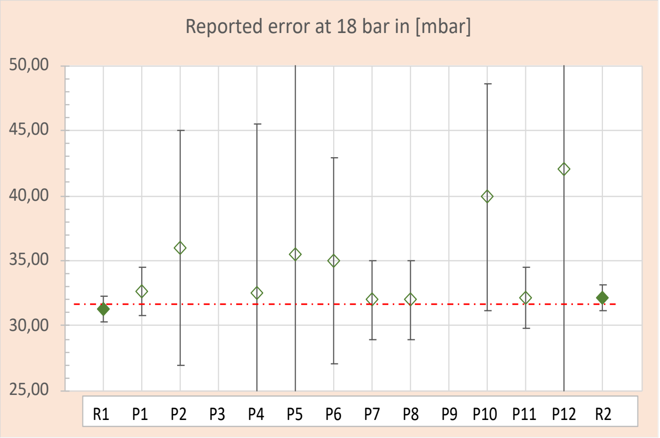

Figure 11: Reported average error and uncertainty at 18 bars. Drift between reference data +0,9 mbar

Comment: Participant P10 and P12 only delivered calibration data up to this pressure point.

Table 12: Measurement point 5 at 24 bars

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	24,025	24,067	42,10	1,0	
P1	24,017	24,060	43,44	2,24	**0,32**
P2	24,072	24,116	44,00	19	**0,07**
P3					
P4	24,000	24,044	43,00	13	**0,03**
P5	24,004	24,048	43,50	15	**0,06**
P6	24,000	24,047	46,50	8,04	**0,48**
P7	23,999	24,040	40,50	4,0	**-0,49**
P8	24,010	24,055	45,00	60	**0,04**
P9					
P10					
P11	24,000	24,042	42,722	2,94	**0,04**
P12					
R2	24,025	24,068	43,05	1,0	
R1&R2			**42,575**	**1,48**	

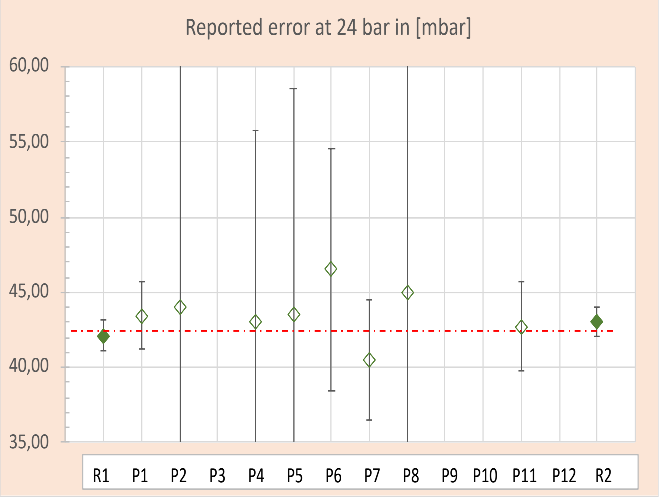

Figure 12: Reported average error and uncertainty at 24 bars. Drift between reference data +0,95 mbar

Table 13: Measurement point 6 at 30 bars

Partici-pant	Reference pressure [bar]	Displayed value [bar]	Reported error [mbar]	Specified uncertainty [mbar]	En-value
R1	30,031	30,084	52,30	1,0	
P1	30,020	30,070	49,59	2,66	**-0,93**
P2	30,206	30,261	55,50	19	**0,17**
P3					
P4	30,000	30,054	43,00	13	**-0,72**
P5	30,004	30,062	57,50	15	**0,35**
P6	30,000	30,055	54,75	8,48	**0,29**
P7	29,999	30,044	45,00	4,0	**-1,75**
P8	30,010	30,070	60,00	60	**0,13**
P9					
P10					
P11	30,000	30,052	52,368	3,29	**0,03**
P12					
R2	30,031	30,084	52,20	1,0	
R1&R2			**52,25**	**1,05**	

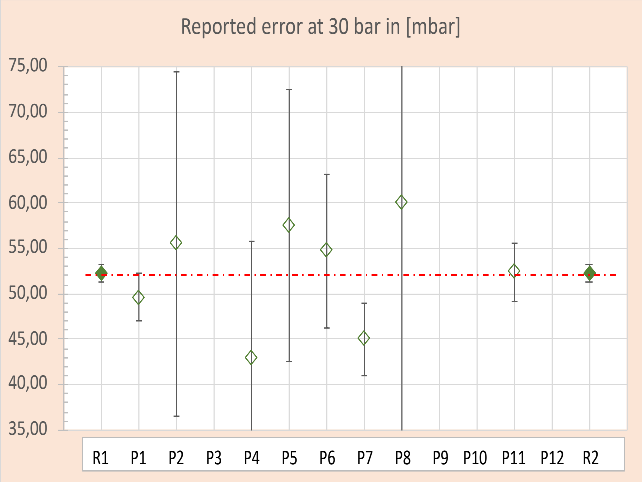

Figure 13: Reported average error and uncertainty at 30 bars. Drift between reference calibration data -0,1 mbar

Comments:

By using the averages from increasing and decreasing pressure values at the stipulated pressure points a pronounced hysteresis will influence the reported error and the En-value directly. Table 14 below lists the difference in error downward to upward direction. As can be seen most differences disappear or are very small. However, some differences influence the En-calculation strongly. In one named situation above, it seemed most fair to only use the upward error in the comparison but not necessary in the example below. Empty cells mean there were no calibrations performed.

Table 14. Hysteresis data at various pressure points – Error at decreasing minus error at increasing pressure.

Participant	-0,5 bar	0,3 bar	0,5 bar	6 bar	12 bar	18 bar	24 bar
	mbar	mbar	mbar	mbar	mbar	mbar	mbar
R1	0	0,05	0	0	0	0	0
P1	0	0	0	0	0	0	0
P2	0,2	-0,04	0	0,01	1,3	0,5	-6
P3	-0,1	0,1	0,1				
P4				2	3	3	3
P5	0	0	0	0	1	-1	3
P6	0,05	-0,05	0	0	0,5	0	0
P7	-0,5	1,9	1,4	8	2	8	7
P8	0	0	-0,1	1	0	0	10
P9	0	0	0				
P10	0	0,153	0,195	-0,051	-0,022	2,743	
P11	0,029	-0,001	0,000	-0,277	-0,350	0,203	-0,123
P12							
R2	-0,05	0,05	0	0	0	0	0

Influence on **En-values**, depending on if the error concerns increasing or decreasing pressure or an average of both – example P7.

pressure level [bar]	up [mbar]	average [mbar]	down [mbar]
6	-1,28	**-0,08**	1,13
12	-1,49	**-1,19**	-0,89
18	-1,13	**0,08**	1,28
24	-1,31	**-0,49**	0,33
30	-2,24	**-1,75**	-1,27

Comments on the calibration certificates

-- not a part of the intercomparison

Among observables in the certificates, it can be named that one laboratory specified the result as correction whereas all others specified the measurement error. One laboratory used the unit kPa – as an equivalent to bar. Whereas some participants supplied a separate certificate for each of the three measurement ranges others gave one certificate for each instrument. One participant sent one certificate for all three ranges. In most cases the uncertainty figures in the certificates were identical with the ones in the excel-protocol. In case they were higher in the certificate those values were used in the report tables.

Some laboratories are giving all calibrated points and the mean value.

Some laboratories are giving a diagram where the hysteresis is demonstrated

Some laboratories are indicating the warmup period.

Some laboratories refer to the specification from the manufacturer even if this was not the question in the intercomparison and indicates if the equipment passes or fails.

Information on the decision rule that was not requested by the organizer but was done in different ways by some laboratories such as:

- Referring to the principles described on their web
- Explaining in a diagram
- Explaining the application in words

All laboratories except one have an accreditation but 4 laboratories are indicating that they are not using their CMC values as the uncertainty values.

Additions and changes to the DRAFT report

In the draft report only the average (increasing and decreasing pressure) for the stated error was displayed. Now, although it was not a focus, this is also done for the reported reference values and the protocolled instrument readings, in some cases also for the stated uncertainties. In two situations (due to big hysteresis effects) only the error in increasing points was reported. In the received comments also a handling error was appointed and corrected. An extra table at the end was added indicating that some participants obviously had problems addressed as hysteresis effects, that however, should not be addressed to the sensor in question. Also, some minor adjustments in the text and layout were performed.

Final conclusions

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

The uncertainty claims do vary pretty much between participants. The intercomparison documents 123 En values and only 5 are higher than 1 and two close to 1. All the high En values are related to accredited laboratories. The uncertainty claims do vary pretty much.

Acknowledgement

We gratefully thank the member of the advisory board and expert in pressure calibrations Aykurt Altintas, Force Denmark as well as the main evaluator of the results Peter Lau.

We also acknowledge the primary calibrations by RISE Sweden that supported the ILC with reference calibrations

Annex 1 ILC pressure 2021:1
Published on https://smquality.se/

Annex 2 Revised description of the intercomparison/ILC
Published on https://smquality.se/

Annex 3 Reporting forms

Reporting form for preliminary calibration results

Laboratory:			Comparison ID
Name:			
e-mail:			
Date of reporting:			

Calibration intercomparison of 2 Pressure gauges

Date of calibration

Pressure Gage 1 **Range** **-1 to 0 bar** certificate ID

Sugested calibration points	Reference value	Measured value	Stated measu-rement error	Stated measure-ment uncertainty
[bar]	[bar]	[bar]	[bar]	[bar]
0				
-0,5				
-0,95				
-0,95				
-0,5				
0				

CMC-value of your laboratory

Please tick the box

Number of cycles performed

Barometric pressure

Pressure Gage 1 **Range** **0 to 1 bar** certificate ID

Air temperature

Sugested calibration points	Reference value	Measured value	Stated measu-rement error	Stated measure-ment uncertainty
[bar]	[bar]	[bar]	[bar]	[bar]
0				
0,3				
0,5				

Height difference calibration object Reference

1				
1				
0,5				
0,3				
0				

Pressure Gage 2 **Range** **0 to 30 bar** certificate ID

Sugested calibrat-ion points	Reference value	Measured value	Stated measu-re-ment error	Stated measure-ment uncertainty
[bar]	[bar]	[bar]	[bar]	[bar]
0				
6				
12				
18				
24				
30				
30				
24				
18				
12				
6				
0				

CMC-value of your laboratory
Please tick the box

Number of cycles performed
Barometric press-sure
Air temperature
Height difference calibration object Reference

Date of receipt of calibration objects	
Date of dispatch	
Used reference equipment	
Traceability to	

Please feel free to give com-ments:

References:

- ISO/IEC 17043:2010 Conformity assessment – General requirements for proficiency testing
- ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories
- ISO 13528 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)