Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC) of the calibration in the length area – part 3 (callipers)

The case carrying all equipment for calibration.

Weight 10 kg

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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.

This report is a part of reports in ILC length containing separate reports on gauge blocks, micrometers and an analog dial gauge as well.

Advisory group

The intercomparison has followed the recommendations of the advisory group during several meetings. The advisory group has defined the set-up of instruments that should be included in the ILC length 2021:1 intercomparison as well as the choice of measuring points that is defined to be included in the evaluation of the results.

The members of the advisory group are Mikael Frennberg, Quality Control in Metrology Sweden, Peter Lau MNE konsult and Håkan Källgren SMQ.

Information about the intercomparison

The information about the intercomparison was given 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 Length 2021:1 referred to in annex 1 in this report

Detailed information as a **description of the intercomparison/ILC published on smquality.se**

and enclosed as annex 2 in this report.

List of objects

Calliper outside analog 0-150 mm

Calliper outside digital 0-150 mm

All objects above were included in one parcel.

Participants could choose which object(s) they wanted to calibrate.

Participating laboratories and measuring scheme for the comparison

Laboratory	**Calibration week**	**Address**
RISE reference laboratory	16	Borås, Sweden
Elastocon AB	17	Brämhult, Sweden
SM Kalibrering AB	18	Kulltorp, Sweden
Sandvik Materials Technology kalibreringscentrum	19	Sandviken, Sweden
Mitutoyo Scandinavia AB	20	Upplands Väsby, Sweden
Transport to Germany	21	
Saliger-Gruppe GmbH	22	Gladbeck, Germany
Wocken Industriepartner GmbH & Co.KG	23	Meppen, Germany
QS-Grimm GmbH	24	Gutach, Germany
Reserve Germany if delays		
Melutec Metrology GmbH	26	Allmersbach im Tal, Germany
Testo Industrial Services GmbH	27	Kirchzarten, Germany
Kolb & Baumann GmbH & Co.KG	28	Aschaffenburg, Germany
esz AG	29	Eichenau, Germany
Kyocera-Unimerco Tooling A/S	30	Sunds, Denmark
DSB Vedligehold A/S, Mekanisk Kalibrering	31	Aarhus, Denmark
Koneteknologiakeskus Turku Oy	32	Turku, Finland
Element Metech AB	33	Trollhättan Sweden
RISE-reference laboratory	34	Borås, Sweden

There were some challenges and delays during the program and the last certificates were received during week 50.

A majority performed a calibration on all equipment others only some objects. During the exercise all together 194 calibrations were performed. Some laboratories decided to let several staff in the same laboratory to do the different calibrations.

Most of the participants have an accreditation by SWEDAC, DANAK, FINAS or DAkkS.

Principles on the calibration in general

The reference laboratory calibrated all equipment prior to the calibrations by the first participant (in the ILC) and the reference laboratory made a second calibration after all calibrations by the participants.

The organiser made a preliminary follow up after each individual calibration by the participants to find if there were some problems on the objects. The main purpose for doing so was to achieve as equal conditions as possible for all participants.

Further it was checked that no significant problem had occurred before the next participant could start its calibration.

Conditions and transport during the measurement period

A special case having special filters and insulation for humidity and vibrations was used for the transportation

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 following points which were important for the inter-comparison outcome. They were not allowed to perform any type of adjustment on the objects.

The laboratories further were encouraged to use their 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 parameters / measuring points on the objects:

- Analog callipers — Outside measurement 2,5, 50 and 150 mm Inside measurement 10 mm, depth measurement 25mm
- Digital callipers — Outside measurement 2,5, 50 and 150 mm Inside measurement 10 mm, depth measurement 25mm

The participant was allowed to record other points as described in their method and issue calibration certificates according to their method. However, the comparison was only evaluated and executed in the points (parameters) mentioned above.

Planning and instruction details

The laboratories were asked to send original calibration data in pre-defined forms (enclosed in annex 3) in digital form as PDF files or excel files by e-mail before transporting to next laboratory. The final calibration certificate should then be sent to the organizer within one week.

The evaluator used the principles of the ISO/IEC 17043:2010 in the reporting.

The participants should deliver calibration certificates, which at least stated the measured values together with a belonging uncertainty for the points stated above.

It was possible to provide additional information or supplementary documentation eventually needed to understand the results.

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: +46705774931

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.
- 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.

Report Part 3 callipers

Considering 15 laboratories from four different countries of which four with several operators performing the calibration work the timeline could be kept quite well. The following up of eventual drift based on the excel protocols, however, was not as successful as planned. Firstly, some of them were rather delayed so that the protocols didn't arrive in time order. Secondly, several values were later replaced in the certificate. Also, several of the calibration certificates arrived extremely late. Thus, even the compilation was delayed and two certificates are still missing.

Analysis of the calibration results

The instructions concerning the calibration of the callipers contained two requirements. The participant should treat this calibration as if it were to a regular customer, which means each one should follow its method and present a calibration certificate in the usual way but use the prescribed measurement points.

The information asked for comparison was the correction values for 5 measuring points for each of the two callipers. Each of these correction values c_i is compared to a corresponding reference correction c_{ref} defined by the average correction supplied by Rise the Swedish National Metrology Institute, who calibrated the two instruments before and after the inter-comparison exercise.

Along with each correction all participants including the reference laboratory Rise delivered their estimated measurement uncertainties U_i. The reference uncertainty U_{ref} is defined as uncertainty by Rise plus half of the eventual difference found over the time of the measurements.

The main information collected is the En-value defined by

$$En = \frac{|c_i - c_{ref}|}{\sqrt{U_i^2 + U_{ref}^2}}$$

Where for each calibrated point

c_i: Single measurement correction value, index i counts the various participants.

c_{ref}: Reference correction for comparison – provided from reference laboratory.

U_i: The estimated expanded uncertainty (k=2) stated by each laboratory

U_{ref}: The estimated expanded uncertainty (k=2) of the reference value

The expression in the denominator is a measure for the uncertainty in the difference in the nominator.

For an acceptable result the En-value should not exceed the value of 1.

The information asked for comparison was the length and the flatness and parallelism.

Inter-comparison reference value and uncertainty

For the two callipers Rise performed 10 calibrations before and 10 after the round robin. As consequence, the inter-comparison reference values for all measurement points and their belonging uncertainties were calculated as

$$c_{ref} = \frac{c_{ref}(1)+c_{ref}(2)}{2} \text{ and } \quad U_{ref} = U(R_1) + \left[\frac{c_{ref}(1)-c_{ref}(2)}{2}\right]$$

However, no change was found between the two times 10 results. Thus, the second equation had no effect. The reference uncertainty is directly defined by the uncertainty of the reference laboratory.

Traceability for the reference values R1 and R2 at each point

The traceability for the reference laboratory RISE is established by regular calibrations of the laboratory's standards traceable to the realisation of the metre at RISE in Borås.

The results from calibration of the equipment at the reference laboratory are documented in the following calibration certificates at the primary and final calibration respectively.

Calibration certificates -- reference laboratory

	Initial calibration	Final calibration
Analog calliper	1050101-139547-K07	1050101-139547-K14
Digital calliper	1050101-139547-K06 rev2	1050101-139547-K13

Results analogue calliper

The following tables and diagrams list the participants with an identity increasing from P1 to P15, which however is not in time order. This participant identity is kept the same for the different calibration objects and in the four different reports

Table 1. first measurement point – outside at 2,5 mm

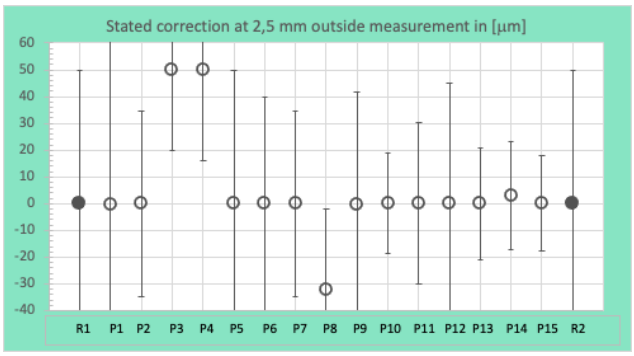


Diagram 1

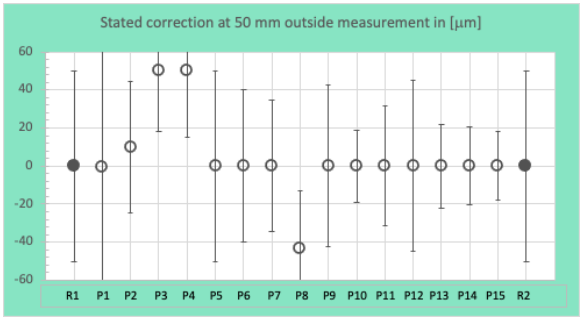
15 correction results of which only three deviate noticeably from all the others and the two reference values.
The results are not listed in time order but randomly numbered. The participant identification is the same for all different calibration objects. An empty row thus means that this instrument was not calibrated by a certain participant.

Table 2 measurement point 2 outside at 50 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	49,9999	50,00	-0,1	50	
P1	49,99982	50,00	-0,18	65	**0,00**
P2	50,0000	49,99	10	34,5	**0,17**
P3	50,00004	49,95	50,04	32	**0,84**
P4	50,0000	49,95	50	34,8	**0,82**
P5	49,9999	50,00	-0,1	50	**0,00**
P6	50,0000	50,00	0,0	40	**0,00**
P7	50,0000	50,00	0,0	34,5	**0,00**
P8	50,0000	50,04	-43	30	**-0,74**
P9	50,00026	50,00	0,26	42,5	**0,01**
P10	50,00008	50,00	0,08	18,9	**0,00**
P11	50,00015	50,00	0,15	31,5	**0,00**
P12	50,0000	50,00	0	45	**0,00**
P13	50,00011	50,00	0,11	22	**0,00**
P14	49,99999	50,00	-0,01	20,5	**0,00**
P15	50,0001	50,00	0,1	18	**0,00**
R2	49,9999	50,00	-0,1	50	
R1&R2	**49,9999**	**50,00**	**-0,1**	**50**	

Table 3 measurement point 3 outside at 100 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	149,9994	150,00	-0,6	50	
P1	150,00033	150,00	0,33	65	**0,01**
P2	150,0000	149,98	20	34,5	**0,34**
P3	150,0007	149,95	50,7	35	**0,84**
P4	150,0000	149,95	50	36,3	**0,82**
P5	150,0002	150,00	0,2	50	**0,01**
P6	150,0000	150,01	-10	40	**-0,15**
P7	150,0000	150,00	0,0	34,5	**0,01**
P8	150,0000	150,012	-12	30	**-0,20**
P9	150,00017	150,00	0,17	45,5	**0,01**
P10	149,99989	149,99	9,89	19,2	**0,20**
P11	150,00033	150,00	0,33	34,5	**0,02**
P12	150,0000	150,00	0,0	45	**0,01**
P13	149,99999	150,00	-0,011	23	**0,01**
P14	149,9958	150,017	-21,2	21,5	**-0,38**
P15	150,0006	150,00	0,6	18	**0,02**
R2	149,9994	150,00	-0,6	50	
R1&R2	**149,9994**	**150,00**	**-0,6**	**50**	



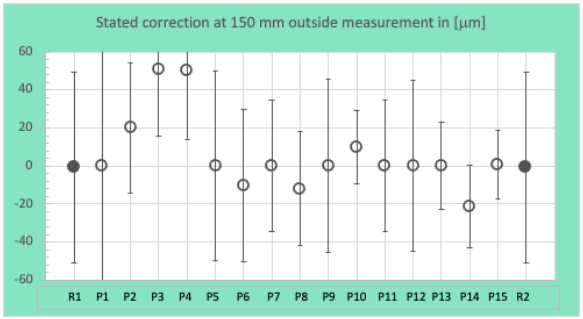


Diagram 2 corrections at 50 mm outside Diagram 3 corrections at 150 mm outside

Comment: Diagrams 1 and 2 are almost identical, whereas the variation increases between participants in diagram 3

Table 4 measurement point 4 - inside 10 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	9,9980	10,00	-2,0	50	
P1	9,99998	10,00	-0,02	65	**0,01**
P2	10,0030	10,00	3,0	34,5	**0,06**
P3	9,9987	10,00	-1,3	30	**-0,01**
P4	10,0000	10,02	-20	33,3	**-0,32**
P5	9,9992	10,00	-0,8	50	**0,00**
P6	20,0000	19,99	10	40	**0,17**
P7	10,0000	10,00	0,0	34,5	**0,01**
P8	10,0000	9,998	2,0	30	**0,04**
P9	10,00077	10,00	0,77	41,3	**0,02**
P10	10,0018	9,95	51,8	18,9	**0,98**
P11	9,9979	10,05	-52,1	30,3	**-0,88**
P12	25,0000	25,00	0,0	45	**0,01**
P13	10,00155	10,00	1,55	21	**0,04**
P14	9,9984	10,01	-11,6	20,1	**-0,20**
P15	9,9916	10,00	-8,4	39	**-0,12**
R2	9,9980	10,00	-2,0	50	
R1&R2	**9,9980**	**10,00**	**-2,0**	**50**	

Table 5 measurement point 5 - depth 25 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	25,0000	25,00	0,0	50	
P1	25,00005	25,00	0,05	65	**0,01**
P2	25,0000	25,00	0,0	34,5	**0,01**
P3	25,00005	25,00	0,05	31	**0,01**
P4	25,0000	25,00	0,0	31,3	**0,01**
P5	25,0000	25,00	0,0	50	**0,01**
P6	24,9950	24,99	5	40	**0,09**
P7	25,0000	25,00	0,0	34,5	**0,01**
P8	25,0000	24,961	39	30	**0,68**
P9	24,99999	25,00	-0,02	41,8	**0,01**
P10	25,00014	25,00	0,14	18,9	**0,01**
P11	25,00021	25,00	0,21	30,8	**0,01**
P12	22,8000	22,79	10	45	**0,16**
P13	24,99976	25,00	-0,24	21	**0,01**
P14	25,00006	25,00	0,06	20,3	**0,01**
P15	25,00020	25,00	0,20	26	**0,01**
R2	25,0000	25,00	0,0	50	
R1&R2	**25,0000**	**25,00**	**0,0**	**50**	

Comment: Most participants delivered more than one result per measurement point in their calibration certificates. For the table the value from the middle of the shank was used, which coincided with the value from the excel-protocol.

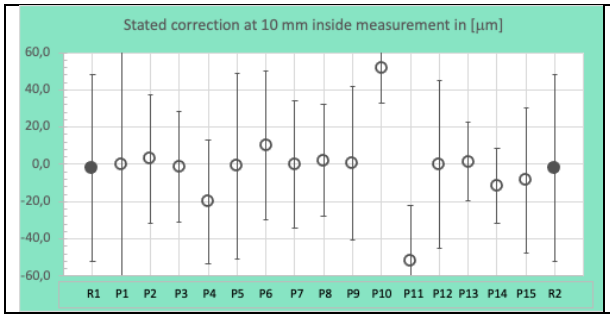


Diagram 4 measurement point 4 inside 10 mm

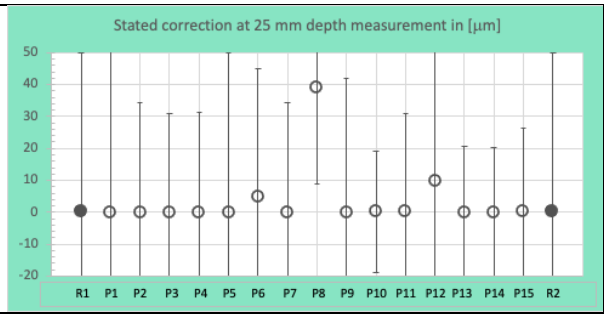


Diagram 5 measurement point 5 – depth 25 mm

Results digital calliper

Table 6. measurement point 1 - outside 2,5 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	2,5000	2,50	0,0	30	
P1	2,49987	2,50	-0,13	33	**0,00**
P2					
P3	2,50004	2,51	-9,96	30	**-0,23**
P4	2,5000	2,50	0,0	20	**0,00**
P5	2,5000	2,50	0,0	40	**0,00**
P6	2,5000	2,50	0,0	30	**0,00**
P7	2,5000	2,50	0,0	34,5	**0,00**
P8	9,5000	9,499	1,0	13	**0,03**
P9	2,49977	2,50	-0,23	30,1	**-0,01**
P10	2,50014	2,51	-9,86	18,9	**-0,28**
P11	2,50012	2,50	0,12	30,1	**0,00**
P12	10,3000	10,30	0,0	35	**0,00**
P13	2,50005	2,51	-9,95	21	**-0,27**
P14	2,50002	2,497	3,02	15	**0,09**
P15	2,5002	2,50	0,2	18	**0,01**
R2	2,5000	2,50	0,0	30	
R1&R2	**2,5000**	**2,50**	**0,0**	**30**	

Comment:

The resolution in the table was chosen with all used decimals to allow recalculation of the En-value.

Even here two participants determined the correction/error at two deviating points. This however, does not seem to be of importance.

Participant 2 only calibrated the analogue caliper.

Again, all En-values are very low, which might be an indication for an unnecessary large uncertainty claim. This is valid for all five measurement points.

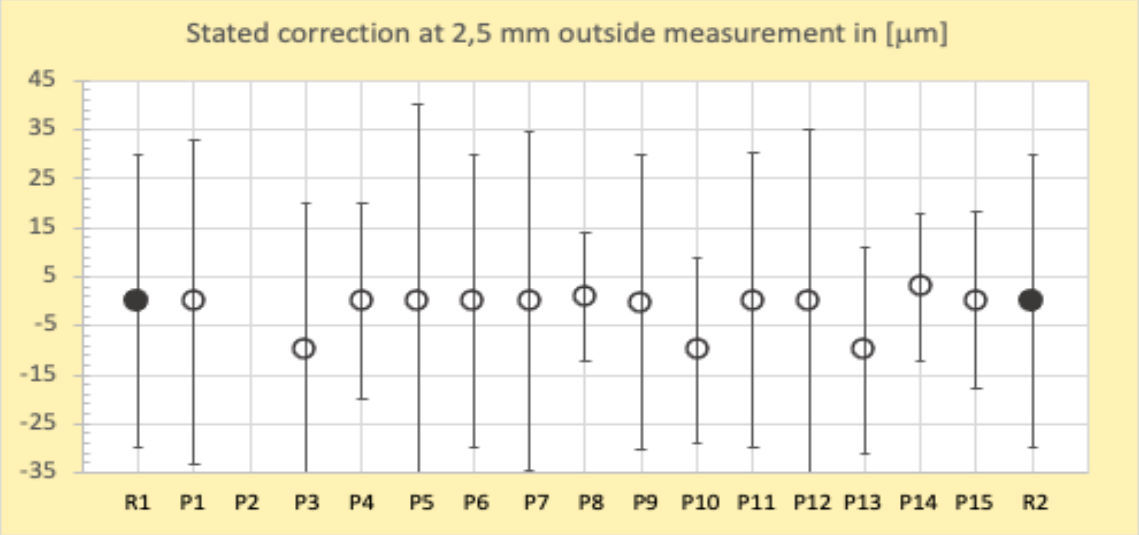


Diagram 6. At measurement point 1 - 2,5 mm outside measurement
All results coincide quite well.

Comment: In the following diagrams different scales are used to exaggerate the small differences between the different participants.

Table 7. measurement point 2 outside 50 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	49,9999	49,99	9,9	30	
P1	49,99982	49,99	9,82	33	**0,00**
P2					
P3	50,00004	49,99	10,04	32	**0,00**
P4	50,0000	49,99	10,0	20,8	**0,00**
P5	49,9999	50,00	-0,1	40	**-0,20**
P6	50,0000	50,00	0,0	30	**-0,23**
P7	50,0000	50,00	0,0	34,5	**-0,22**
P8	50,0000	50,001	-1	13	**-0,33**
P9	50,00026	49,98	20,26	31,5	**0,24**
P10	50,00008	50,00	0,08	18,9	**-0,28**
P11	50,00015	49,99	10,15	31,5	**0,01**
P12	50,0000	50,00	0,0	35	**-0,21**
P13	50,00011	50,00	0,11	22	**-0,26**
P14	49,99999	49,987	12,99	15,5	**0,09**
P15	50,0001	50,00	0,1	18	**-0,28**
R2	49,9999	49,99	9,9	30	
R1&R2	**49,9999**	**49,99**	**9,9**	**30**	

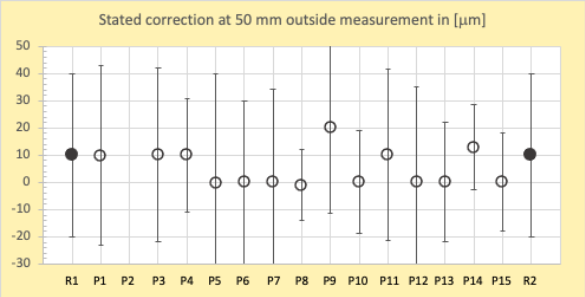


Diagram 7 50 mm outside

Table 8. measurement point 3 outside 150 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	149,9994	150,00	-0,6	30	
P1	150,0003	150,00	0,33	33	**0,02**
P2					
P3	150,0007	149,99	10,7	35	**0,25**
P4	150,0000	149,99	10,0	22,3	**0,28**
P5	150,0002	150,00	0,2	40	**0,02**
P6	150,0000	150,00	0,0	30	**0,01**
P7	150,0000	149,99	10,0	34,5	**0,23**
P8	150,0000	150,003	-3,0	13	**-0,07**
P9	150,00017	149,99	10,17	34,5	**0,24**
P10	149,99989	150,01	-10,11	19,2	**-0,27**
P11	150,00033	149,99	10,33	34,5	**0,24**
P12	150,0000	149,99	10,0	35	**0,23**
P13	149,99999	150,00	-0,01	23	**0,02**
P14	149,9958	149,99	5,8	16,5	**0,19**
P15	150,0006	150,00	0,6	18	**0,03**
R2	149,9994	150,00	-0,6	30	
R1&R2	**149,9994**	**150,00**	**-0,6**	**30**	

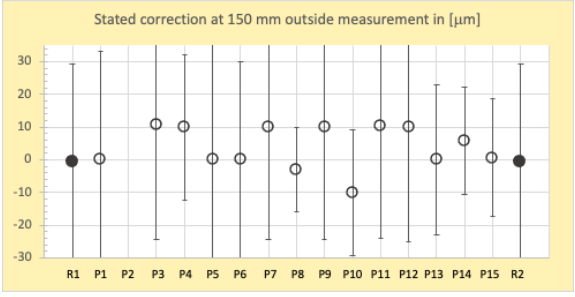


Diagram 8 150 mm outside

Table 9 measurement point 4 inside 10 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	9,9980	9,99	8,0	30	
P1	9,99998	10,00	-0,02	33	**-0,18**
P2					
P3	9,9987	10,00	-1,30	30	**-0,22**
P4	10,0000	9,99	10,0	24,3	**0,05**
P5	9,9992	9,97	29,2	40	**0,42**
P6	20,0000	19,99	10,0	30	**0,05**
P7	10,0000	9,99	10,0	34,5	**0,04**
P8	10,0000	10,002	-2,0	13	**-0,31**
P9	10,00077	10,00	0,77	30,3	**-0,17**
P10	10,0018	9,99	11,8	18,9	**0,11**
P11	9,9979	10,00	-2,1	30,3	**-0,24**
P12	25,0000	25,00	0,0	35	**-0,17**
P13	10,00155	10,00	1,55	22	**-0,17**
P14	9,9984	10,00	-1,6	15,1	**-0,29**
P15	9,9916	9,99	1,6	39	**-0,13**
R2	9,9980	9,99	8,0	30	
R1&R2	**9,9980**	**9,99**	**8,0**	**30**	

Table 10 measurement point 5 depth 25 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	25,0000	25,02	-20,0	30	
P1	25,00005	25,02	-19,95	33	**0,00**
P2					
P3	25,00005	25,20	-20,0	31	**0,00**
P4	25,0000	25,01	-10,0	22,3	**0,27**
P5	25,0000	25,02	-20,0	40	**0,00**
P6	24,9950	25,00	-5,0	40	**0,30**
P7	25,0000	25,00	0,0	34,5	**0,44**
P8	25,0000	24,988	12,0	13	**0,98**
P9	24,99999	25,02	-20,0	30,8	**0,00**
P10	25,00014	25,01	-9,9	18,9	**0,29**
P11	25,00021	25,03	-29,8	30,8	**-0,23**
P12	22,8000	22,80	0,0	35	**0,43**
P13	24,99976	25,02	-20,2	21	**-0,01**
P14	25,00006	24,99	10,1	15,3	**0,89**
P15	25,0002	25,01	-9,8	26	**0,26**
R2	25,0000	25,02	-20,0	30	
R1&R2	**25,0000**	**25,02**	**-20,0**	**30**	

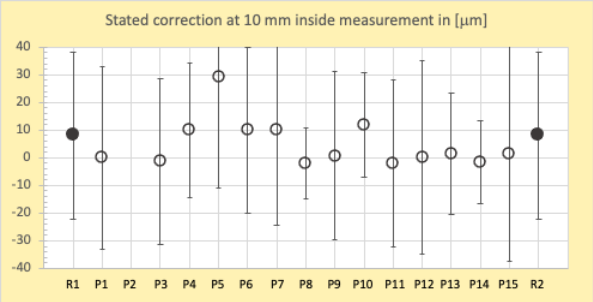


Diagram 9 10 mm inside

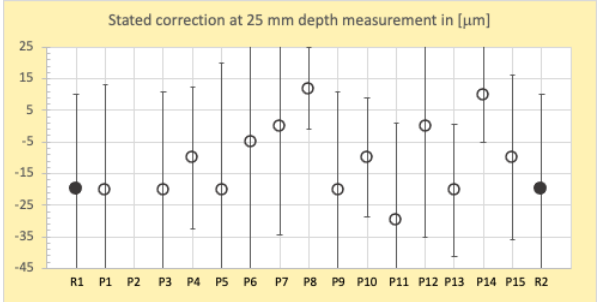


Diagram 10 25 mm depth

Additional calibration results

Altogether 15 participants calibrated the analogue and digital calliper. Among some laboratories other persons from the staff also performed these calibrations. Thus, two results were reported from participant P6, four from participant P7, two from participant P15 and P10. Even participant P12 supplied some additional calibration results, however not for the two callipers. Due to the ambition to give all laboratories the same attention only one results is shown above. The extra results are collected in separate tables and diagram below having the same numbering. These results are compared to the same reference data than in the earlier tables. That means these results including the En-values are directly comparable to the previous tables and diagrams. The idea with those additional calibrations was to qualify the work of those persons under the equivalent circumstances.

Table 1b. – analogue calliper - measurement point 1 - outside 2,5 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	2,5000	2,500	0,0	50	
P6-2	2,5000	2,500	0,0	40	**0,00**
P7-2	2,5000	2,500	0,0	34,5	**0,00**
P7-3	2,5000	2,500	0,0	34,5	**0,00**
P7-4	2,5000	2,500	0,0	34,5	**0,00**
P15-2	2,5002	2,500	0,2	18	**0,00**
P10-2	2,5001	2,500	0,14	18,9	**0,00**
P12-2					
R2	2,5000	2,500	0,0	50	
R1&R2	**2,5000**	**2,5000**	**0,0**	**50**	

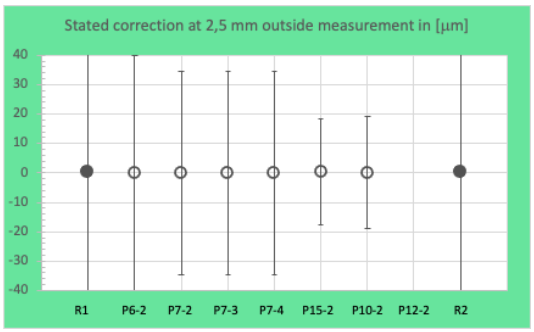


Diagram 1b.

Table 2b. – analogue calliper - measurement point 2 - outside 50 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	49,9999	50,000	-0,1	50	
P6-2	50,0000	50,000	0,0	40	**0,00**
P7-2	50,0000	50,000	0,0	34,5	**0,00**
P7-3	50,0000	50,000	0,0	34,5	**0,00**
P7-4	50,0000	50,000	0,0	34,5	**0,00**
P15-2	50,0001	50,000	0,1	18	**0,00**
P10-2	50,00008	50,000	0,08	18,9	**0,00**
P12-2					
R2	49,9999	50,000	-0,1	50	
R1&R2	**49,9999**	**50,000**	**-0,1**	**50**	

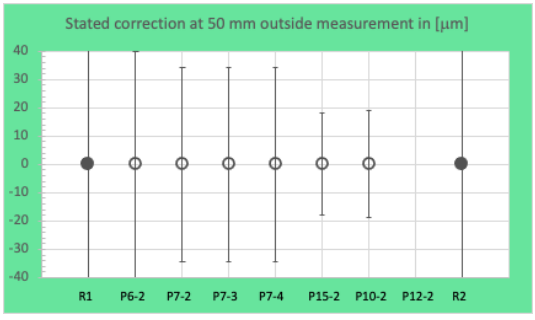


Diagram 2b.

Table 3b. – analogue calliper - measurement point 3 - outside 150 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	149,9994	150,00	-0,6	50	
P6-2	150,0000	150,00	0,0	40	**0,01**
P7-2	150,0000	150,00	0,0	34,5	**0,01**
P7-3	150,0000	149,975	25,0	34,5	**0,42**
P7-4	150,0000	150,00	0,0	34,5	**0,01**
P15-2	150,0006	150,00	0,6	18	**0,02**
P10-2	149,9999	150,00	-0,11	19,2	**0,01**
P12-2					
R2	149,9994	150,00	-0,6	50	
R1&R2	**149,9994**	**150,00**	**-0,6**	**50**	

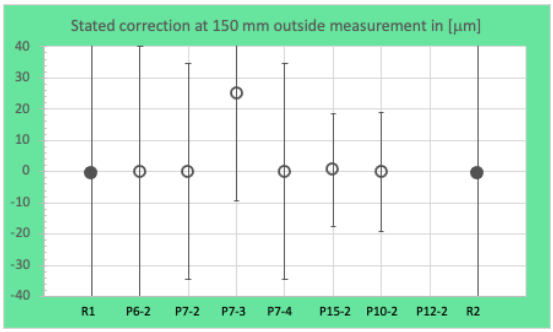


Diagram 3b.

Table 4b. – analogue calliper - measurement point 4 - inside 10 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	9,9980	10,00	-2,0	50	
P6-2	20,0000	20,00	0,0	40	**0,03**
P7-2	10,0000	10,00	0,0	34,5	**0,03**
P7-3	10,0000	10,00	0,0	34,5	**0,03**
P7-4	10,0000	9,975	25,0	34,5	**0,44**
P15-2	9,9916	10,00	-8,4	39	**-0,10**
P10-2	10,0018	10,00	1,80	18,9	**0,07**
P12-2					
R2	9,9980	10,00	-2,0	50	
R1&R2	**9,9980**	**10,00**	**-2,0**	**50**	

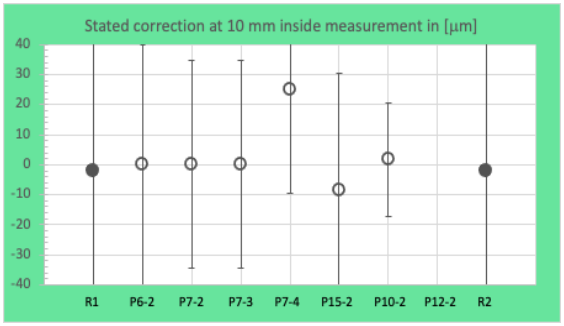


Diagram 4b.

Table 5b. – analogue calliper - measurement point 5 - depth 25 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	25,00000	25,00	0,0	50,0	
P6-2	24,995	25,000	-5,0	40,0	**-0,08**
P7-2	25,0000	25,00	0,0	34,5	**0,00**
P7-3	25,00000	25,00	0,0	34,5	**0,00**
P7-4	25,00000	24,975	25,0	34,5	**0,41**
P15-2	25,00020	25,00	0,2	26,0	**0,00**
P10-2	25,00014	25,00	0,14	18,9	**0,00**
P12-2					
R2	25,00000	25,00	0,0	50,0	
R1&R2	**25,00000**	**25,00**	**0,0**	**50,0**	

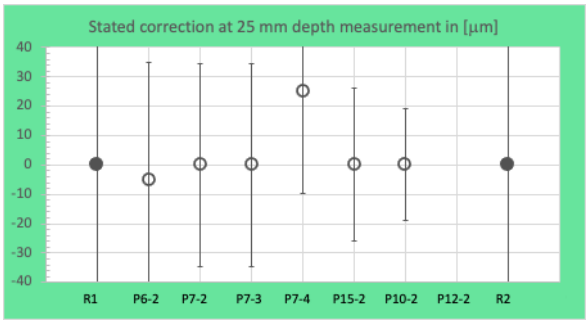


Diagram 5b.

Comment: This table and diagram were updated after detection of an error in the draft reort.

Table 6b. – digital calliper - measurement point 1 - outside 2,5 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	2,5000	2,50	0,00	30	
P6-2	2,5000	2,50	0,00	30	**0,00**
P7-2	2,5000	2,49	10,00	34,5	**0,22**
P7-3	2,5000	2,50	0,00	34,5	**0,00**
P7-4	2,5000	2,50	0,00	34,5	**0,00**
P15-2	2,5002	2,51	-9,80	18	**-0,28**
P10-2	2,5001	2,51	-9,86	18,9	**-0,28**
P12-2					
R2	2,5000	2,50	0,00	30	
R1&R2	**2,5000**	**2,50**	**0**	**30**	

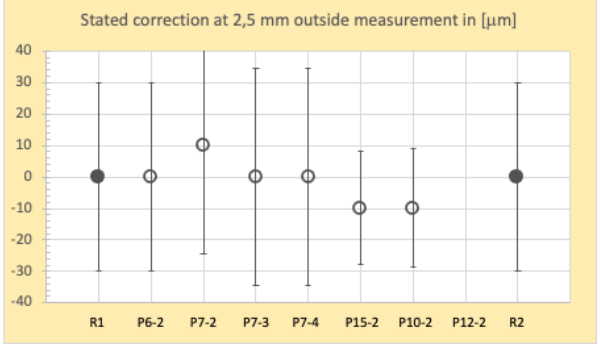


Diagram 6b.

Table 7b. – digital calliper - measurement point 2 - outside 50 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	49,9999	49,99	9,90	30	
P6-2	50,0000	49,99	10,00	30	**0,00**
P7-2	50,0000	49,99	10,00	34,5	**0,00**
P7-3	50,0000	50,00	0,00	34,5	**-0,22**
P7-4	50,0000	49,99	10,00	34,5	**0,00**
P15-2	50,0001	50,00	0,10	18	**-0,28**
P10-2	50,00008	49,99	10,08	18,9	**0,01**
P12-2					
R2	49,9999	49,99	9,90	30	
R1&R2	**49,9999**	**49,99**	**9,9**	**30**	

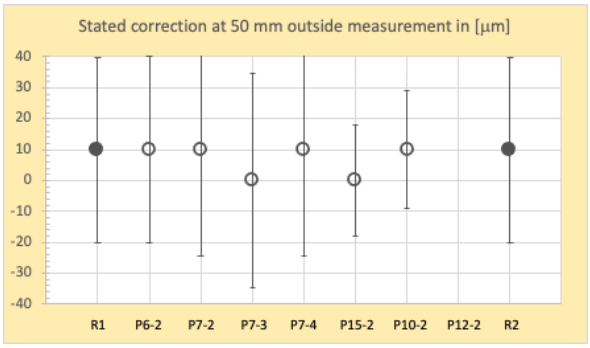


Diagram 7b.

Table 8b. – digital calliper - measurement point 3 - outside 150 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	149,9994	150,00	-0,60	30	
P6-2	150,0000	150,00	0,00	30	**0,01**
P7-2	150,0000	149,99	10,00	34,5	**0,23**
P7-3	150,0000	149,99	10,00	34,5	**0,23**
P7-4	150,0000	150,00	0,00	34,5	**0,01**
P15-2	150,0006	150,00	0,60	18	**0,03**
P10-2	149,9999	150,00	-0,11	19,2	**0,01**
P12-2					
R2	149,9994	150,00	-0,60	30	
R1&R2	**149,9994**	**150,00**	**-0,6**	**30**	

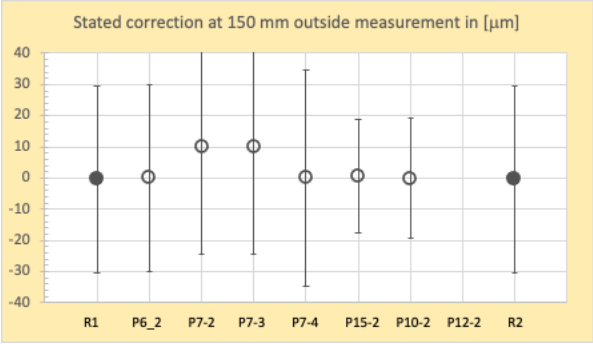


Diagram 8 b.

Table 9b. – digital calliper - measurement point 4 - inside 10 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	9,9980	9,99	8,00	30	
P6-2	20,0000	20,01	-10,00	30	**-0,42**
P7-2	10,0000	9,99	10,00	34,5	**0,04**
P7-3	10,0000	9,99	10,00	34,5	**0,04**
P7-4	10,0000	9,97	30,00	34,5	**0,48**
P15-2	9,9916	9,99	1,60	39	**-0,13**
P10-2	10,0018	10,00	1,80	18,9	**-0,17**
P12-2					
R2	9,9980	9,99	8,00	30	
R1&R2	**9,9980**	**9,99**	**8,0**	**30**	

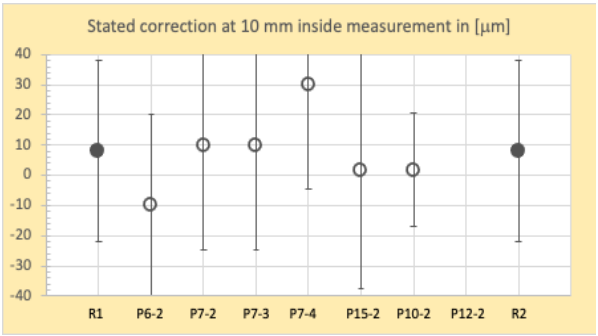


Diagram 9b.

Table 10b. – digital calliper - measurement point 5 - depth 25 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	25,0000	25,02	-20,00	30	
P6-2	24,9950	25,00	-5,00	40	**0,300**
P7-2	25,0000	25,00	0,00	34,5	**0,437**
P7-3	25,0000	25,00	0,00	35	**0,437**
P7-4	25,0000	25,00	0,00	34,5	**0,437**
P15-2	25,0002	25,01	-9,80	26	**0,257**
P10-2	25,00014	25,00	0,14	19	**0,568**
P12-2					
R2	25,0000	25,02	-20,00	30	
R1&R2	**25,0000**	**25,02**	**-20,0**	**30**	

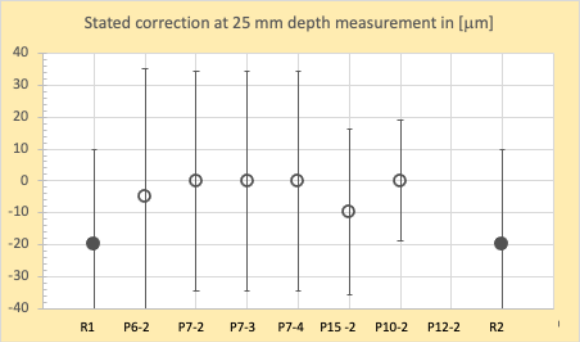


Diagram 10 b.

Comments on calibration certificates

-not a part of the intercomparison

Calibration certificates are issued in the local language and in some cases in English as well. Some laboratories refer their calibration methods to national and international standards and documents while other laboratories refer to methods they have evaluated locally.

Most of the laboratories document the status of the object at arrival. Description about visual check and cleaning of the objects are good in many cases.

Description of traceability for calibrations are normally very clear.

Description about visual check and cleaning of the objects are good in many cases.

Most of the laboratories refer to the MRA.

All laboratories indicate the reference temperature to 20°C and some give the range of temperature to be ±0,5°C up to ±1,5°C.

Nearly all laboratories use the term deviation/abweichung to describe error or correction.

Uncertainty is sometimes described as a fixed value and sometimes as a formula using a fixed term and a part related to the length. This gives some complications for clients.

Some laboratories describe the principles for conformity decision or by giving a diagram based on ILAC-G8:09/2019.

Final conclusions

In this inter comparison all the participants could demonstrate a convincing capacity to calibrate the various callipers that are involved in this ILC. Most of the laboratories took part in the comparison of all equipment, that will be reported separately.

The details in the evaluations could have been more specific if the reference values could have had smaller values on uncertainty, but the results show that the clients using the participant laboratories will get correct results.

The number of En-values were 192 calculated with 0 values higher than 1, that is a fantastic result.

The ability of different laboratories to prove the correctness of their CMC values is not a part of an intercomparison of this type. It is up to the various laboratories to evaluate their results according to the requirements in ISO/IEC 17025:2017 as specified in point 7.7.3.

Acknowledgement

We gratefully thank the member of the advisory board and expert in length calibrations Mikael Frennberg 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 Length 2021:1 published on www.smquality.se

Annex 2 Revised description of the intercomparison/ILC published on www.smquality.se

Annex 3 reporting form for preliminary calibration results.

Observe that only the left part could be seen by the participants.

Reporting form for preliminary calibration results			
Laboratory:		Comparison ID	
Name:			
e-mail:			
Reporting date:			

2 Callipers		**OBSERVE that no adjustments are allowed -except zeroing**			
		Date of calibration			
Calliper 1		**Analog**	**0 to 150 mm**		
Calibration points	Used reference	Measured value	Stated correction	Stated measure-ment uncertainty	Number of repetitions
	[mm]	[mm]	[mm]	[mm]	1
outside - 2,5 mm					CMC-value? ☐ yes3
outside - 50 mm					
outside - 150 mm					
inside - 10 mm					
depth - 25 mm					
		Date of calibration			
Calliper 2		**Digital**	**0 to 150 mm**		
Calibration points	Used reference	Measured value	Stated correction	Stated measure-ment uncertainty	
	[mm]	[mm]	[mm]	[mm]	
outside - 2,5 mm					
outside - 50 mm					
outside - 150 mm					
inside - 10 mm					
depth - 25 mm					

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)
- ILAC-G8:09/2019 Guidelines on Decision Rules and Statements of Conformity