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 2 (micrometers)

The case carrying all equipment for calibration.

Weight 10 kg

Author

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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 covering the results related to micrometer. There are separate reports on gauge blocks, callipers and analog dial gauge

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

Micrometer, outside analog 75-100 mm

Micrometer outside digital 25-50mm

Tubular inside micrometer (2-point) 50-75 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. This could not always be done of different reasons.

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:

- Outside analog micrometer 80,1 85,3- and 100-mm, flatness and parallelism
- Outside digital micrometer 27,5 37,0 and 50 mm, flatness and parallelism
- Tubular inside micrometre (analog) 57,7 67,6 and 75 mm,

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 2– micrometers

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

Analysis of the calibration results

In the instructions for the micrometers two requirements were raised. First every participant should follow its own method to perform the calibration and second the calibration certificate should be presented as if it were to a usual customer.

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

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

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

For each calibrated point

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

c_{ref}: Reference value 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.

Inter-comparison reference value and uncertainty

18 calibrations performed by Rise before and after the round robin resulted in 9 differences of which 6 were zero and 3 showed a slight difference, which however were below the stated uncertainties.

As consequence, the inter-comparison reference values for all measurement points and their belonging uncertainties were calculated as

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

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
Outside analog micrometer	105101-139547-K05	105101-139547-K12
Outside digital micrometer	105101-139547-K04	105101-139547-K11
Tubular inside micrometrer	105101-139547-K03	105101–139547-K10

Results outside analog micrometer

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 to this ILC.

Table 1. Measurement point 1: at 80,1 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[∝m]	[∝m]	
R1	80,10000	80,1010	-1,0	5,0	
P1	80,00017	80,0000	0,08	5,0	**0,15**
P2					
P3	80,09991	80,0980	1,91	3,8	**0,46**
P4	8,10000	8,1000	0,0	3,7	**0,16**
P5	80,09991	80,1000	-0,09	12	**0,07**
P6	80,30000	80,3050	-5,0	5,0	**-0,57**
P7	80,10000	80,1010	-1,0	3,01	**0,00**
P8	80,10000	80,0994	0,6	2,0	**0,30**
P9	80,10002	80,0980	2,021	3,8	**0,48**
P10	80,10010	80,1030	-2,9	2,4	**-0,34**
P11	80,09982	80,0990	0,82	3,8	**0,29**
P12	80,10000	80,1000	0,0	3,4	**0,17**
P13	80,09993	80,1000	-0,07	2,5	**0,17**
P14	80,10009	80,0990	1,09	3,8	**0,33**
P15	80,10020	80,1000	0,2	2,0	**0,22**
R2	80,10000	80,1010	-1,0	5,0	
R1&R2	80,10000	80,1010	-1,0	5,0	

Comment:

The first and last row in the table present the two results R1 and R2 from the reference laboratory Rise.
The excel-protocols provided by the participants are copied as single sheets in a common excel-file.
The values shown in the table are linked from each of these sheets into an evaluation sheet.
Before establishing these links all protocol data are checked against the data presented in the belonging calibration certificates.

In the case of P4 there was no certificate available to check the delivered values - probably a writing mistake.

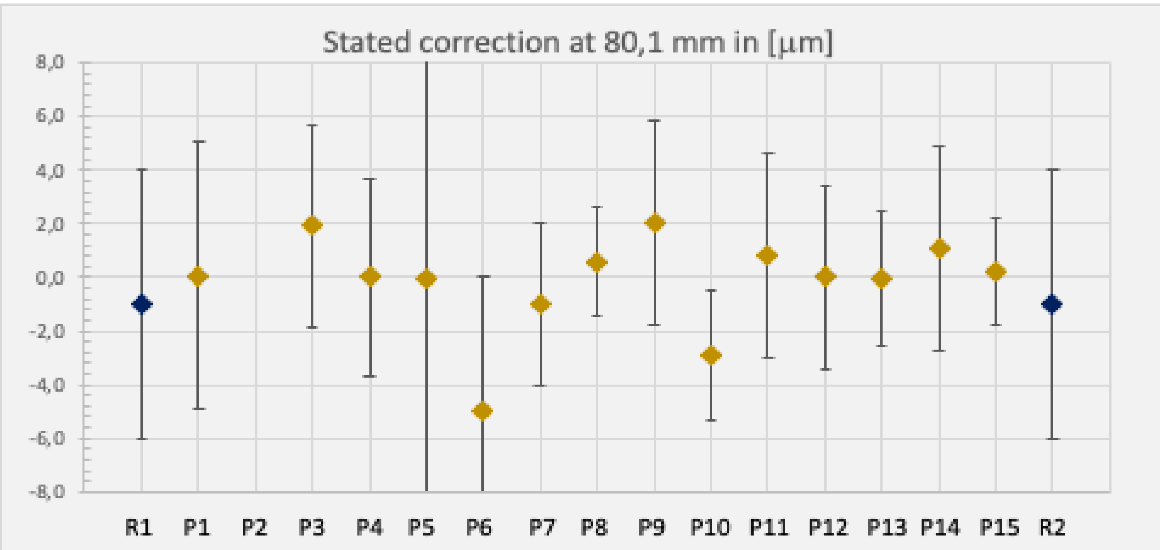


Diagram 1. Reported correction values at measurement point 1. During the exercise no drift could be seen.

Table 2. Measurement point 2: at 85,3 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	85,30000	85,3010	-1,0	5,0	
P1	90,00019	90,0000	0,02	5,0	**0,07**
P2					
P3	85,30014	85,2980	2,14	3,9	**0,39**
P4	85,30000	85,3000	0,0	3,8	**0,07**
P5	85,30004	85,3000	0,04	12	**0,04**
P6	85,10000	85,1050	-5,0	5,0	**-0,61**
P7	85,30000	85,3010	-1,0	3,0	**-0,08**
P8	85,30000	85,2992	0,8	2,0	**0,22**
P9	85,30018	85,2980	2,18	3,9	**0,40**
P10	85,30017	85,3020	-1,83	2,4	**-0,22**
P11	85,29968	85,2990	0,68	3,9	**0,18**
P12	85,30000	85,3000	0,0	3,5	**0,08**
P13	85,29997	85,3000	-0,03	2,6	**0,08**
P14	85,29997	85,2980	1,97	3,9	**0,37**
P15	85,30020	85,3020	-1,8	2,0	**-0,22**
R2	85,30000	85,3000	0,0	5,0	
R1&R2	85,30000	85,3005	-0,5	5,5	

Comment:

The left column contains the identification of the various participants in arbitrary order - not in time order.
The second column identifies the length of the used reference, which not always was a gage block.
The column “measured value” informs about the value read of the micrometre.
The difference between both is the stated correction. Most participants quote the error instead, which was converted into a correction by changing the sign.

The fifth column contains the reported calibration uncertainties.

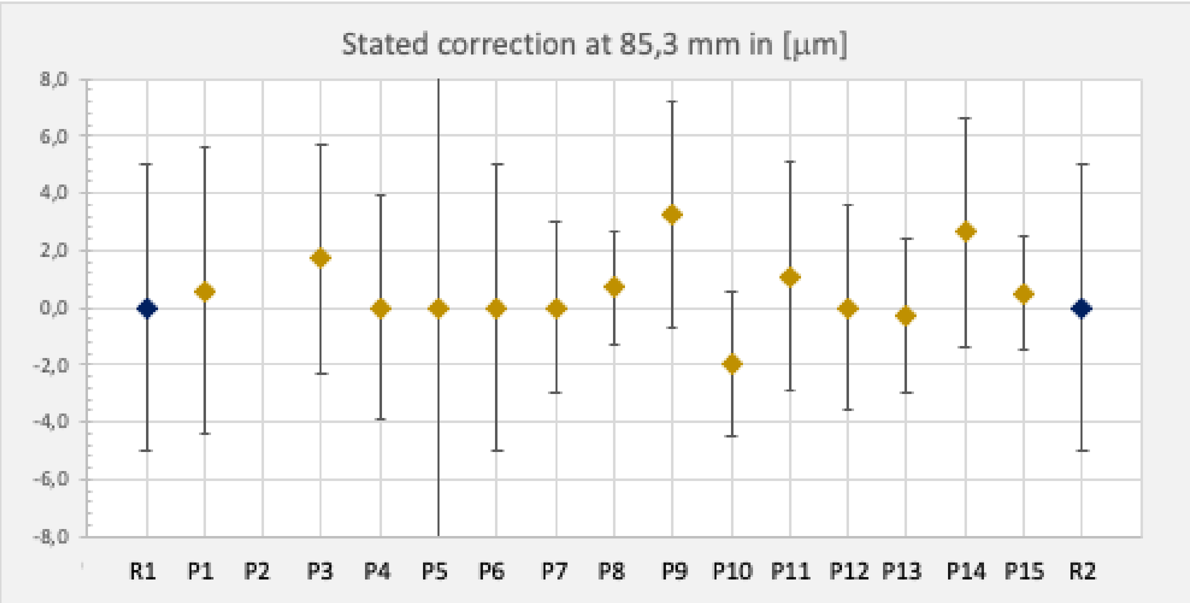


Diagram 2. Reported correction values at measurement point 2 With belonging uncertainty staples.

Table 3. Measurement point 3: at 100 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	100,00000	100,000	0,0	5,0	
P1	99,99996	100,000	0,57	5,0	**0,08**
P2					
P3	99,99973	99,998	1,73	4,0	**0,27**
P4	100,00000	100,000	0,0	3,9	**0,00**
P5	99,99995	100,000	-0,05	12,0	**0,00**
P6	100,00000	100,000	0,0	5,0	**0,00**
P7	100,00000	100,000	0,0	3,0	**0,00**
P8	100,00000	99,9993	0,7	2,0	**0,13**
P9	100,00025	99,997	3,25	4,0	**0,51**
P10	100,00004	100,002	-1,96	2,5	**-0,35**
P11	100,00009	99,999	1,09	4,0	**0,17**
P12	100,00000	100,000	0,0	3,6	**0,00**
P13	99,99973	100,000	-0,27	2,7	**-0,05**
P14	99,99962	99,997	2,62	4,0	**0,41**
P15	100,00050	100,000	0,5	2,0	**0,09**
R2	100,00000	100,000	0,0	5,0	
R1&R2	100,00000	100,0000	0,0	5,0	

Comment:

The reference value used in each table is the bottom line R1&R2 as average between the first and last line. If the stated correction is the same before and after the whole exercise the reference uncertainty is identical with the uncertainty delivered by Rise, which is always the same for a given measurement point. The second calibration is not used to lower the reference uncertainty as it is a completely new measurement.

It can be recognized that the reference laboratory does not provide the lowest uncertainty, which helps to keep En-values low

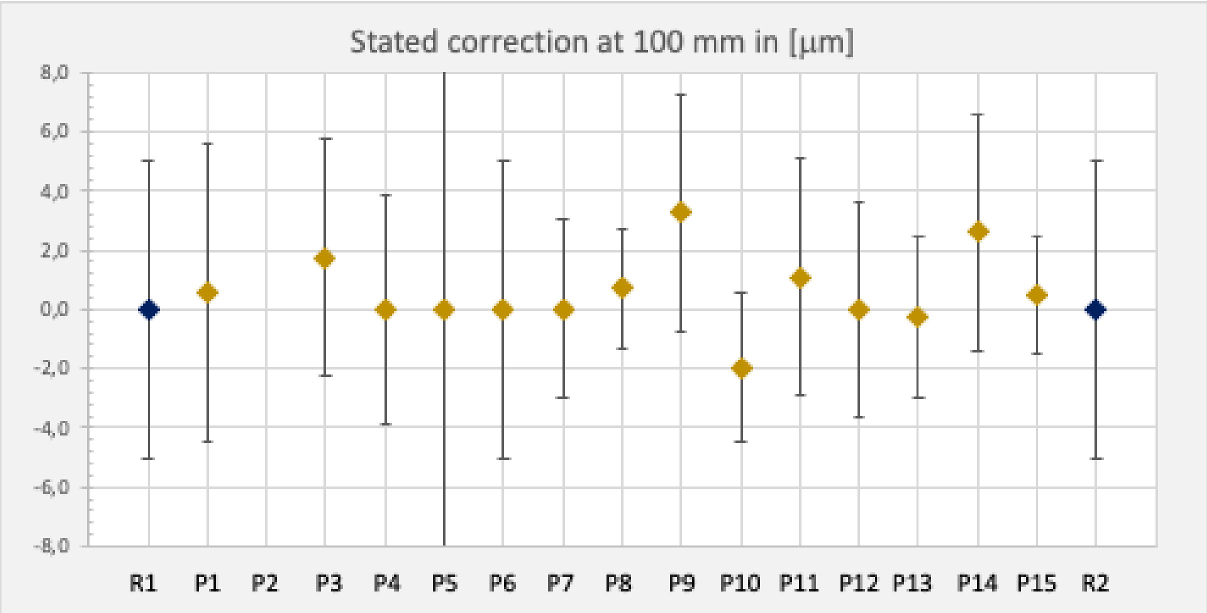


Diagram 3. Reported correction values at measurement point 3 – all with good agreement.

It can be observed that all participants show low En-values, meaning that they perform equivalent calibrations. For this micrometre participant P2 did not deliver a result.

Results outside digital micrometer

Table 4 Measurement point 1: at 27,5 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	27,5000	27,501	-1,0	3,0	
P1	25,00005	25,000	0,2	4,0	**0,14**
P2	27,5000	27,500	0,0	3,5	**0,10**
P3	27,50017	27,501	-0,83	3,3	**-0,07**
P4	27,5000	27,500	0,0	2,1	**0,12**
P5	27,50006	27,500	0,06	5,0	**0,09**
P6	27,5000	27,500	0,0	4,0	**0,09**
P7	27,5000	27,501	-1,0	3,0	**-0,11**
P8	27,5000	27,4998	0,2	2,0	**0,17**
P9	27,49976	27,501	-1,24	3,3	**-0,16**
P10	27,50028	27,503	-2,72	2,1	**-0,54**
P11	27,50008	27,501	-0,92	3,3	**-0,09**
P12	27,5000	27,500	0,0	3,0	**0,11**
P13	27,49962	27,500	-0,38	2,2	**0,03**
P14	27,49983	27,500	-0,17	3,3	**0,07**
P15	27,5004	27,500	0,4	2,0	**0,22**
R2	27,5000	27,500	0,0	3,0	
R1&R2	27,5000	27,5005	-0,5	3,5	

Comment :

From the first R1 to the last calibration R2 a change of 1 micrometre was observed. The reference value therefore was determined to the average of both.

As a consequence the uncertainty was increased with half of this difference.

One participant could not manage to provide the exact reference of 27,5 mm, but supplied a correction close by.

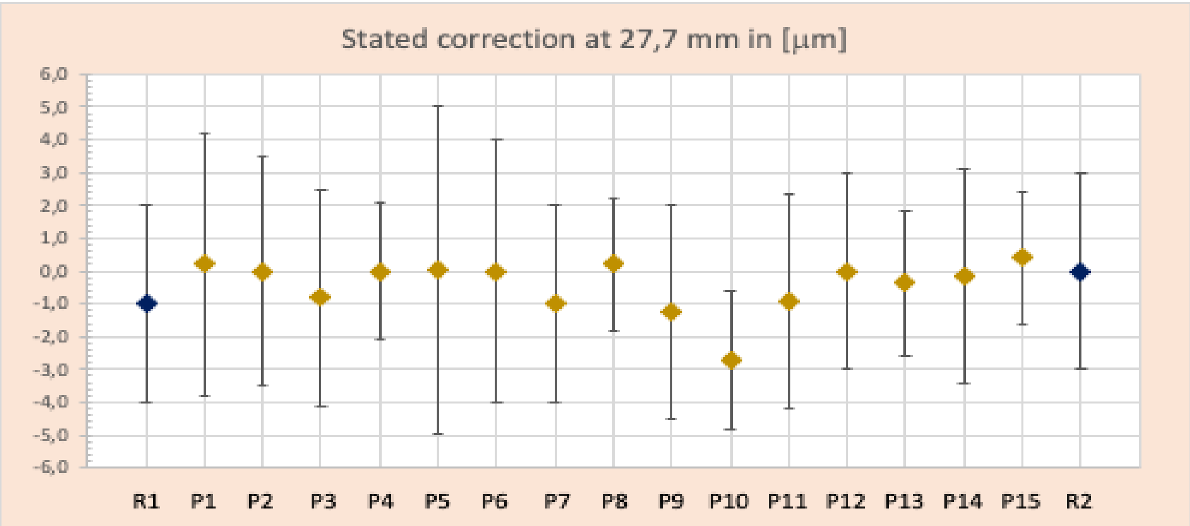


Diagram 4. Reported correction values for digital micrometre at measurement point 1.

Table 5 Measurement point 2: at 37 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	37,9000	37,900	0,0	3,0	
P1	40,00012	40,000	0,85	4,0	**0,17**
P2	37,9000	37,900	0,0	3,5	**0,00**
P3	37,90013	37,900	0,13	3,4	**0,03**
P4	37,9000	37,901	-1,0	2,2	**-0,27**
P5	37,90005	37,900	0,05	5,0	**0,01**
P6	37,8000	37,800	0,0	4,0	**0,00**
P7	37,9000	37,901	-1,0	3,0	**-0,24**
P8	37,9000	37,8997	0,3	2,0	**0,08**
P9	37,90006	37,901	-0,94	3,4	**-0,21**
P10	37,90019	37,903	-2,81	2,1	**-0,77**
P11	37,90005	37,900	0,05	3,4	**0,01**
P12	37,9000	37,900	0,0	3,1	**0,00**
P13	37,89976	37,900	-0,24	2,3	**-0,06**
P14	37,89989	37,900	-0,11	3,4	**-0,02**
P15	37,9003	37,901	-0,7	2,0	**-0,19**
R2	37,9000	37,900	0,0	3,0	
R1&R2	37,9000	37,900	0	3,0	

Comment :

Again the reference 40 mm is close enough to obligatory 37,9 mm to be counted as a regular result.

The resolution in the columns were chosen to reveal as much of the reported details.

Several participants reported the uncertainty values not as fixed numbers, but in form of an equation that was used to determine the tabled values.

No change was observed. Between R1 and R2.

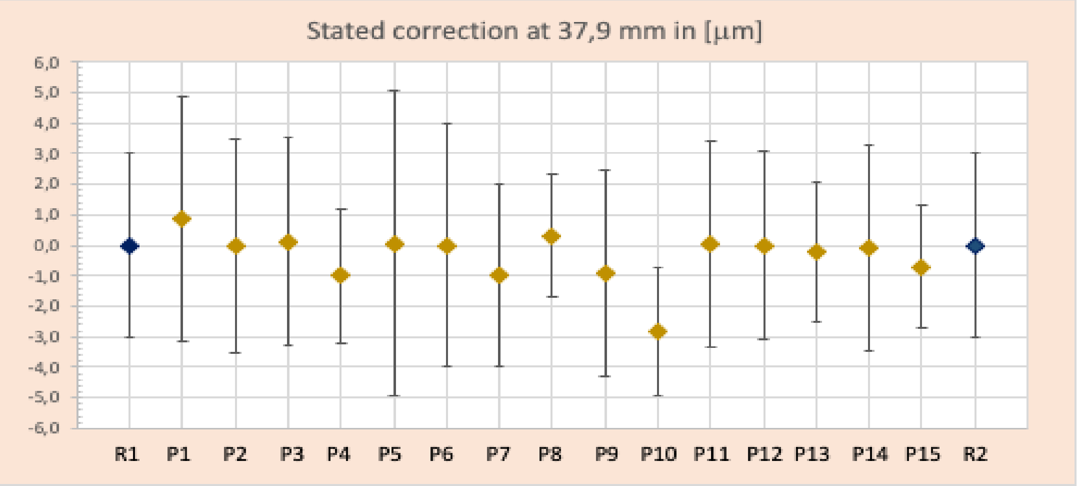


Diagram 5. Reported correction values for digital micrometre at measurement point 2. No change observed over the calibration period.

Table 6 Measurement point 3: at 50 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	49,9999	50,001	-1,1	3,0	
P1	50,00018	50,000	0,41	4,0	**0,09**
P2	50,0000	50,000	0,0	3,5	**0,02**
P3	49,99986	49,999	0,86	3,5	**0,18**
P4	50,0000	50,001	-1,0	2,3	**-0,20**
P5	49,99988	50,000	-0,12	5,0	**0,00**
P6	50,0000	49,999	1,0	4,0	**0,19**
P7	50,0000	50,000	0,0	3,0	**0,02**
P8	50,0000	50,0002	-0,2	2,0	**-0,02**
P9	50,00026	50,001	-0,74	3,5	**-0,12**
P10	50,00008	50,002	-1,92	2,1	**-0,40**
P11	50,00003	50,000	0,03	3,5	**0,02**
P12	50,0000	50,000	0,0	3,1	**0,02**
P13	50,00011	50,000	0,11	2,4	**0,05**
P14	50,00038	50,001	-0,62	3,5	**-0,10**
P15	50,0001	50,000	0,1	2,0	**0,04**
R2	49,9999	49,999	0,9	3,0	
R1&R2	49,9999	50,000	-0,1	4,0	

Comment :

At this distance a considerable shift (but still within the stated uncertainty) was found between the first and last calibration performed from -1,1 to +0,9 micromtre. This of course also increased the reference uncertainty.

Generally, most of the un-certainty values are reason-ably close and all En-values are very low.

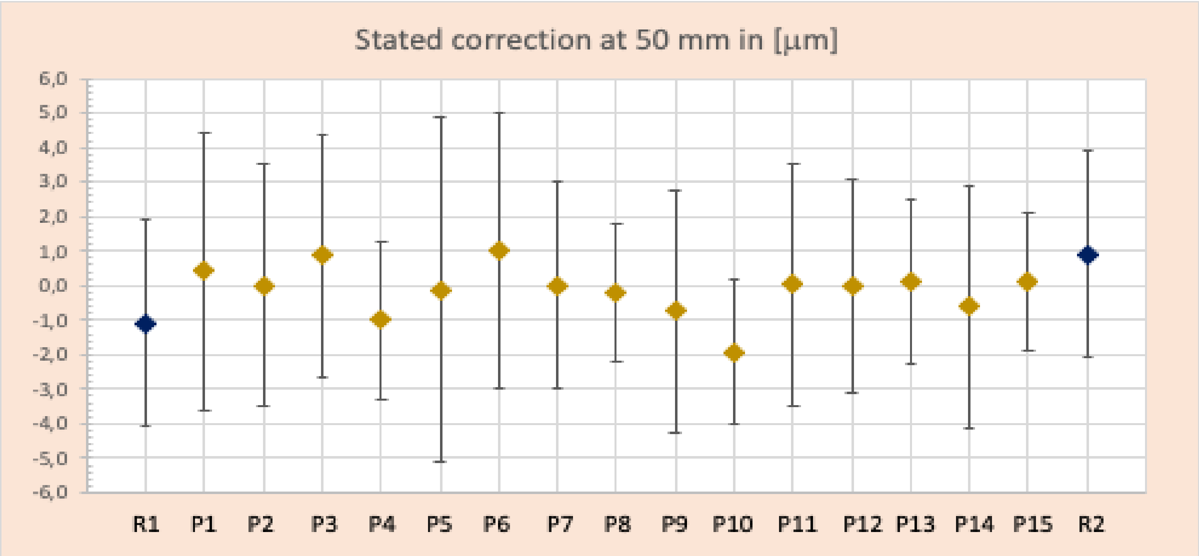


Diagram 6. Reported correction values for digital micrometre at measurement point 3; a marked change observed between R1 and R2. The average is chosen as Reference value.

Results tubular inside analog micrometer

Table 7 Measurement point 1 at 57,7 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	57,6980	57,700	-2,0	3,0	
P1	59,99996	60,001	0,0	19	**0,10**
P2	57,6990	57,700	-1,0	3,8	**0,21**
P3	57,7000	57,7024	-0,4	3,6	**0,34**
P4		57,700		2,8	
P5					
P6	57,7000	57,6976	2,42	5,0	**0,76**
P7					
P8					
P9	57,7000	57,7013	-1,3	3,6	**0,15**
P10	57,7027	57,700	2,7	2,2	**1,26**
P11	57,7000	57,7008	-0,82	3,6	**0,25**
P12					
P13	57,7000	57,7001	-0,1	0,32	**0,63**
P14	57,6949	57,6953	-0,38	3,6	**0,35**
P15	57,7001	57,705	-4,9	2,2	**-0,78**
R2	57,6980	57,700	-2,0	3,0	
R1&R2	57,6980	57,700	-2,0	3,0	

Comment :

Three participants waived calibrating this instrument .

One participant did not fill out the excel-protocoll completly and the missing reference value could not be taken from a calibration certificate as it was not delivered.

One participant P1 took the closest available reference and found no correction need. He stated a real large uncertainty

Another participant P13 on the other hand gave an extreme low uncertainty, which however results within En ≤ 1.

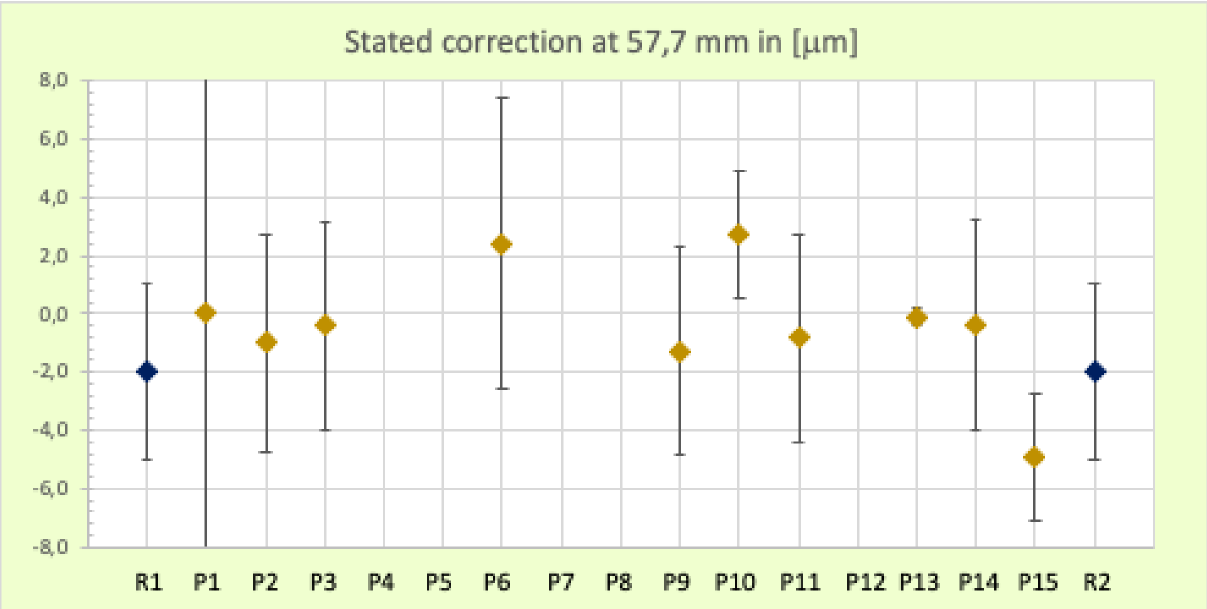


Diagram 7. Reported correction values for inside micrometre at measurement point 1. No drift was observed between R1 and R2.

Table 8 Measurement point 2 at 67,6 mm

Partici-pant	Reference value	Measured value	Stated correction	Stated uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
R1	67,5980	67,600	-2,0	3,0	
P1	70,00024	70,001	0,0	19,0	**0,10**
P2	67,6000	67,600	0,0	3,75	**0,42**
P3	67,6000	67,6017	0,3	3,7	**0,48**
P4		67,601		2,9	
P5					
P6	67,6000	67,5965	3,46	5,0	**0,94**
P7					
P8					
P9	67,6000	67,6013	-1,30	3,7	**0,15**
P10	67,6020	67,600	2,0	2,2	**1,08**
P11	67,6000	67,6014	-1,42	3,7	**0,12**
P12					
P13	67,6000	67,600	0,0	0,3	**0,66**
P14	67,5949	67,5951	-0,15	3,7	**0,39**
P15	67,6001	67,600	0,1	2,2	**0,56**
R2	67,5980	67,600	-2,0	3,0	
R1&R2	67,5980	67,600	-2,0	3,0	

Comment :

Same situation as for measurement point 1.

Most reported uncertainty values are higher than the reference uncertainty provided by Rise. The instrument was stable over time.

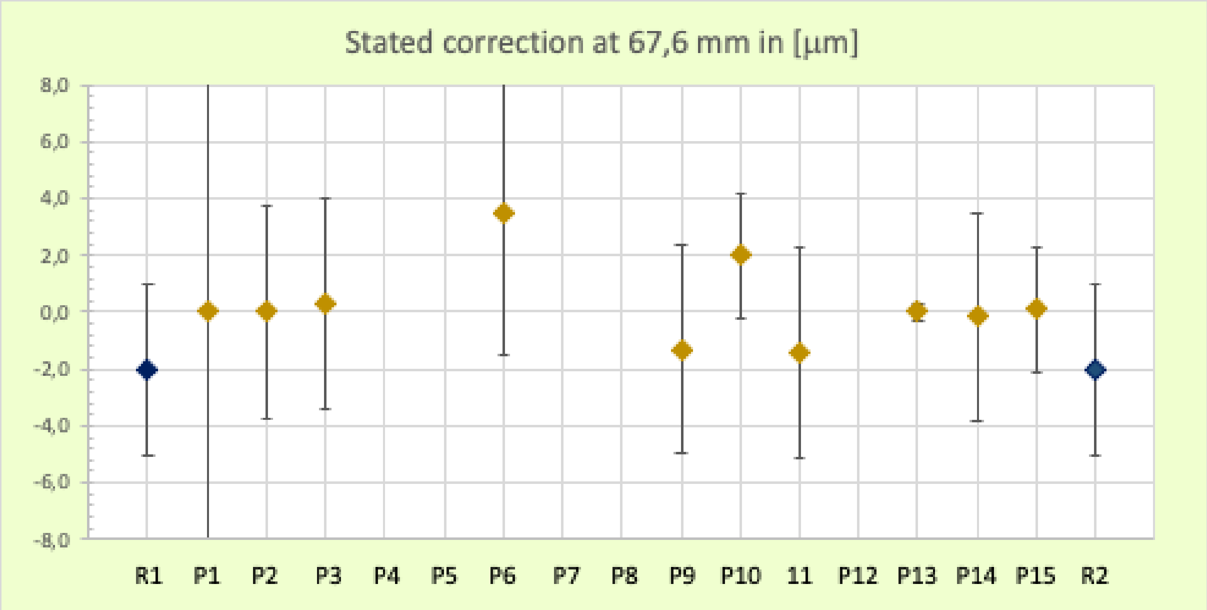


Diagram 8. Reported correction values for inside micrometre at measurement point 2, again no drift indication

Table 9 Measurement point 3 at 75 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	74,9990	75,000	-1,0	3,0	
P1	74,99996	75,002	-2,04	19,0	**-0,05**
P2	75,0030	75,000	3,0	3,75	**0,83**
P3	75,0000	75,0027	-0,7	3,75	**0,06**
P4		75,002		2,9	
P5					
P6	75,0000	74,9988	1,16	5,0	**0,37**
P7					
P8					
P9	75,0000	75,0015	-1,5	3,75	**-0,10**
P10	75,0023	75,000	2,3	2,3	**0,87**
P11	75,0000	75,0019	-1,87	3,75	**-0,18**
P12					
P13	75,0000	75,0009	-0,9	0,35	**0,03**
P14	74,9949	74,9954	-0,46	3,75	**0,11**
P15	75,0001	75,000	0,1	2,2	**0,30**
R2	74,9990	75,000	-1,0	3,0	
R1&R2	74,9990	75,000	-1,0	3,0	

Comment :

All participants use the same stipulated reference length.

No obvious drift in instrument.

No participant found a clear deviating correction leading to an En-value exceeding the acceptable level of En ≥ 1.

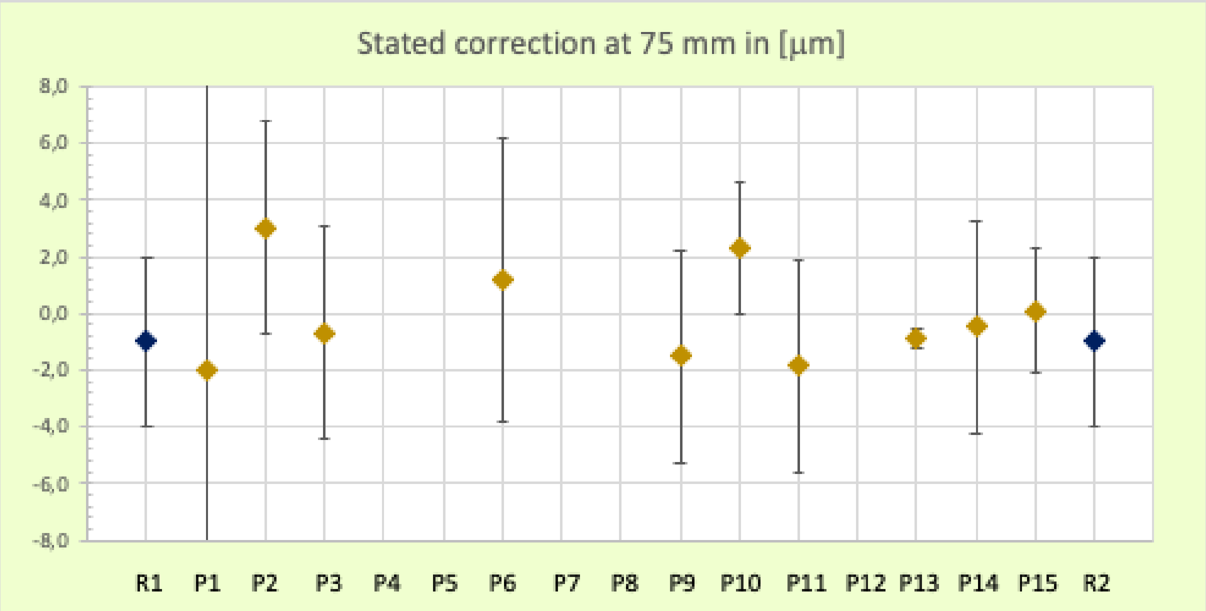


Diagram 9. Reported correction values for inside micrometre at measurement point 3. Even at this point the device under test was stable between R1 and R2.

Evaluation of results of flatness and parallelism

RISE laboratory gave the following results in the calibration certificates before and after circulation.

- Tubular inside micrometre is not indicating results on flatness and parallelism.
- Digital micrometer 25-50 mm flatness before circulation 0,1 ± 0,2 µm and 0,1 ± 0,2 µm after circulation
- Digital micrometer 25-50 mm parallelism before circulation 0,9 ± 0,3 µm and 1,2 ± 0,3 µm after circulation
- Analogue micrometer 75-100 mm, the flatness before circulation 0,1 ± 0,2 µm and 0,1 ± 0,2 µm after circulation
- Analog micrometer 75-100 mm parallelism before circulation 2,9 ± 1 µm and 10 ± 1 µm after circulation.

Comment: The parallelism of the analog micrometer has changed considerably after the circulation.

No real calculated intercomparison values could be done on parallelism and flatness as the participants reported on those in very different ways.

Documentation in calibration certificates in relation to flatness and parallelism

- Several laboratories are not documenting results of flatness and parallelism
- Several laboratories are documenting that flatness and parallelism are approved
- Some laboratories give values on flatness and parallelism but no documented uncertainty

Additional calibration results

Altogether 15 participants calibrated the three micrometres. Among those laboratories different persons from the staff repeated the calibration of these objects; thus, two results were reported from participant P6, four from participant P7, two from participant P15 and P10. P12 as well supplied additional calibration results but not for the micrometres. To keep a straight report giving all laboratories the same attention those extra results are collected in separate tables and diagram below. 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 following tables have the same numbering (with a b added) than before for easier comparison. The idea with those additional calibrations was to qualify the work of those persons under the same circumstances.

Micrometer 1 analog

Table 1b. Measurement point 1: 80,1 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	80,1000	80,101	-1,0	5,0	
P6-2	80,3000	80,303	-3,0	50	**-0,04**
P7-2	80,1000	80,099	1,0	4,0	**0,31**
P7-3	80,1000	80,100	0,0	4,0	**0,16**
P7-4	80,1000	80,100	0,0	4,0	**0,16**
P15-2	80,1002	80,101	-0,8	2,0	**0,04**
P10-2	80,1001	80,103	-2,9	2,4	**-0,34**
P12-2					
R2	80,1000	80,101	-1,0	5,0	
R1&R2	80,1000	80,101	-1,0	5,0	

Diagram 1b

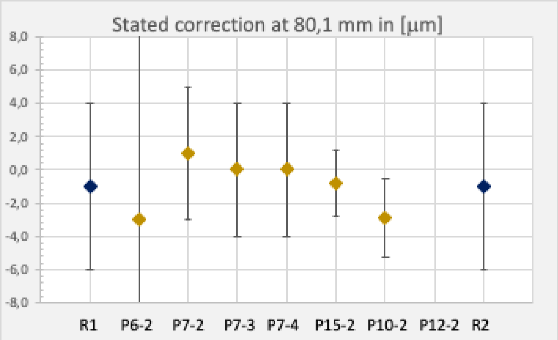


Table 2b. Measurement point 2: 85,3 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	85,3000	85,301	-1	5	
P6-2	85,1000	85,103	-3,0	50	-0,05
P7-2	85,3000	85,299	1,0	4,0	0,22
P7-3	85,3000	85,301	-1,0	4,0	-0,07
P7-4	85,3000	85,301	-1,0	4,0	-0,07
P15-2	85,3002	85,301	-0,8	2,0	-0,05
P10-2	85,30017	85,302	-1,8	2,4	-0,22
P12-2					
R2	85,3000	85,300	0,0	5,0	
R1&R2	85,3000	85,3005	-0,5	5,5	

Diagram 2b

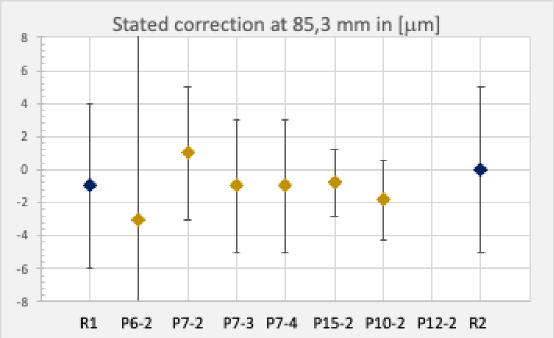
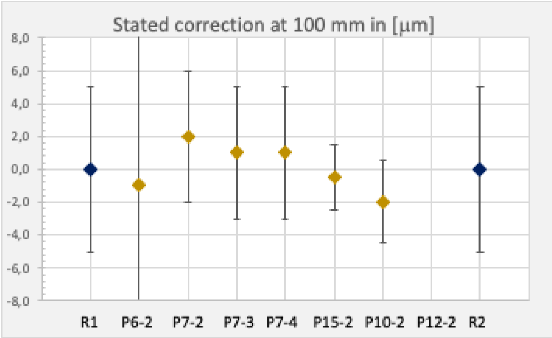


Table 3b. Measurement point 3: 100 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	100,0000	100,000	0,0	5,0	
P6-2	100,0000	100,001	-1,0	50	-0,02
P7-2	100,0000	99,998	2,0	4,0	0,31
P7-3	100,0000	99,999	1,0	4,0	0,16
P7-4	100,0000	99,999	1,0	4,0	0,16
P15-2	100,00050	100,001	-0,5	2,0	-0,09
P10-2	100,00004	100,002	-2,0	2,5	-0,35
P12-2					
R2	100,0000	100,000	0,0	5,0	
R1&R2	100,0000	100,000	0,0	5,0	

Diagram 3b



Mikrometer 2- digital

Table 4b. Measurement point 1: 27,5 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	27,5000	27,501	-1,0	3,0	
P6-2	27,5000	27,502	-2,0	40	-0,04
P7-2	27,5000	27,501	-1,0	3,5	-0,10
P7-3	27,5000	27,500	0,0	3,5	0,10
P7-4	27,5000	27,500	0,0	3,5	0,10
P15-2	27,5004	27,501	-0,6	2,0	-0,02
P10-2	27,5003	27,501	-0,7	2,1	-0,05
P12-2					
R2	27,5000	27,500	0,0	3,0	
R1&R2	27,5000	27,501	-0,5	3,5	

Diagram 4b

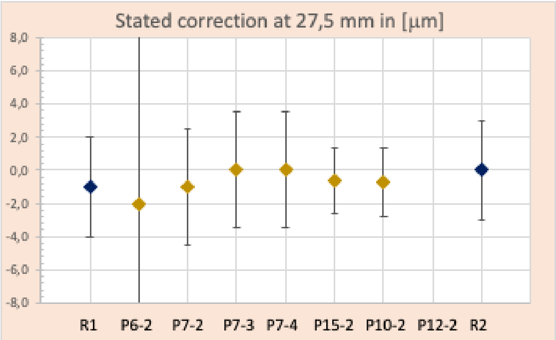


Table 5b. Measurement point 2: 37,9 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	37,9000	37,900	0,0	3	
P6-2	37,8000	37,801	-1,0	40	**-0,02**
P7-2	37,9000	37,901	-1,0	3,5	**-0,22**
P7-3	37,9000	37,901	-1,0	3,5	**-0,22**
P7-4	37,9000	37,901	-1,0	3,5	**-0,22**
P15-2	37,9003	37,902	-1,7	2,0	**-0,47**
P10-2	37,9002	37,902	-1,8	2,1	**-0,49**
P12-2					
R2	37,9000	37,900	0,0	3,0	
R1&R2	37,9000	37,900	0,0	3,0	

Diagram 5b

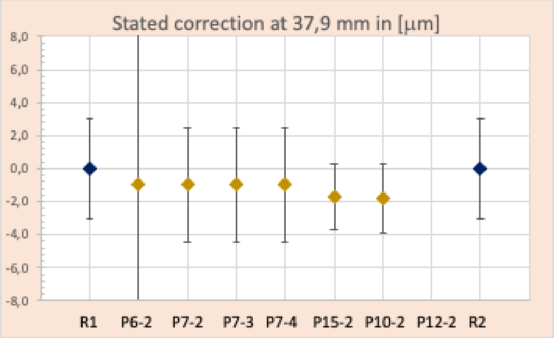
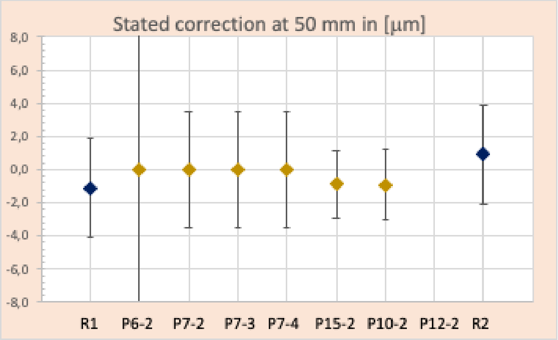


Table 6b. Measurement point 3: 50 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	49,9999	50,001	-1,1	3,0	
P6-2	50,0000	50,000	0,0	40	**0,00**
P7-2	50,0000	50,000	0,0	3,5	**0,02**
P7-3	50,0000	50,000	0,0	3,5	**0,02**
P7-4	50,0000	50,000	0,0	3,5	**0,02**
P15-2	50,0001	50,001	-0,9	2,0	**-0,18**
P10-2	50,0001	50,001	-0,9	2,1	**-0,18**
P12-2					
R2	49,9999	49,999	0,9	3,0	
R1&R2	49,9999	50,000	-0,1	4,0	

Diagram 6b

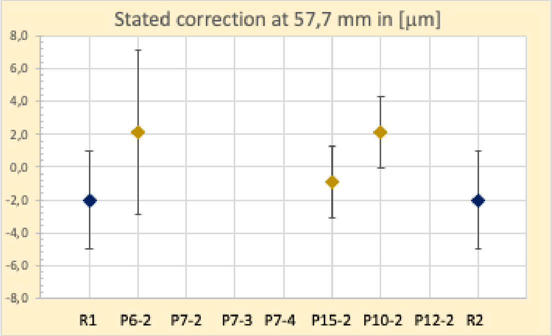


Mikrometer 3 Tubular inside

Table 7b. Measurement point 1: 57,7 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	57,6980	57,700	-2,0	3,0	
P6-2	57,7000	57,69789	2,1	5	**0,70**
P7-2	57,0000	57,7022	-702,2	3,8	**-146**
P7-3	57,0000	57,7013	-701,3	3,8	**-146**
P7-4	57,0000	57,7013	-701,3	3,8	**-146**
P15-2	57,7001	57,701	-0,9	2,2	**0,30**
P10-2	57,7021	57,700	2,1	2,2	**1,10**
P12-2					
R2	57,6980	57,700	-2,0	3,0	
R1&R2	57,6980	57,700	-2,0	3,0	

Diagram 7b



Comment:

All three participants P7-2 to P7-4 seem to have made the same mistake in filling in the excel-protocol. Either it was a writing error, or they read the reference wrong. Their calibration certificate did not contain this detailed information, so it was not possible to correct in a meaningful way. However, there is no doubt that the En-values do not reflect a real measurement result and the corrections are not shown in the diagram.

Table 8b. Measurement point 2: 67,67 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	74,9990	75,000	-1,0	3,0	
P6-2	75,0000	74,9984	1,6	5	**0,45**
P7-2	75,0000	75,0017	-1,7	3,8	**-0,15**
P7-3	75,0000	75,0017	-1,7	3,8	**-0,15**
P7-4	75,0000	75,0024	-2,4	3,8	**-0,29**
P15-2	75,0001	75,001	-0,9	2,2	**0,03**
P10-2	75,0018	75,000	1,8	2,3	**0,74**
P12-2					
R2	74,9990	75,000	-1,0	3,0	
R1&R2	74,9990	75,000	-1,0	3,0	

Diagram 8b

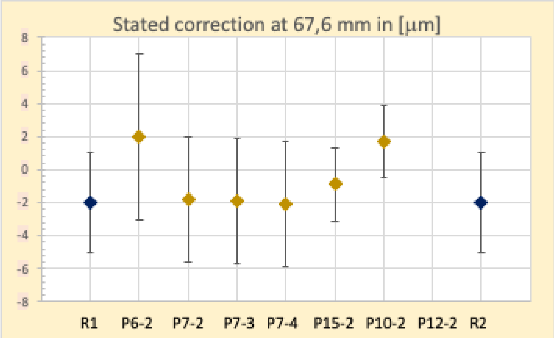
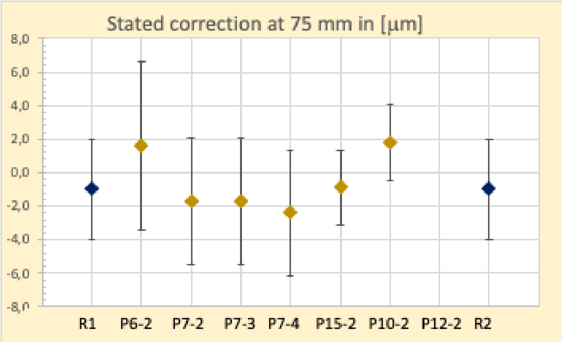


Table 9b. Measurement point 3: 75 mm

Partici-pant	Reference value [mm]	Measured value [mm]	Stated correction [µm]	Stated uncertainty [µm]	En-value
R1	74,9990	75,000	-1,0	3,0	
P6-2	75,0000	74,9984	1,6	5	**0,37**
P7-2	75,0000	75,0017	-1,7	3,8	**-0,11**
P7-3	75,0000	75,0017	-1,7	3,8	**-0,11**
P7-4	75,0000	75,0024	-2,4	3,8	**-0,22**
P15-2	75,0001	75,001	-0,9	2,2	**0,02**
P10-2	75,0018	75,000	1,8	2,3	**0,51**
P12-2					
R2	74,9990	75,000	-1,0	3,0	
R1&R2	74,9990	75,000	-1,0	5,0	

Diagram 9b



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.
Some laboratories document the measurement force.
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 could give 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 micrometers that are involved in this ILC. Most of the laboratories took part in the comparison of all equipment, that will be reported separately.

The number of En-values are 171 and only 9 values higher than 1. This is a very good result and proves that clients to the participant laboratories can trust the results they get in calibrations.

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 Frenn-berg 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:			

3 Micrometers		**OBSERVE that no adjustments are allowed except zeroing**			
		Date of calibration			
Micrometer 1		**Outside analog**	**75 - 100 mm**		
Calibration points	Reference gauge value	Measured value	Stated correction	Stated measure-ment uncertainty	Number of repetitions
[mm]	[mm]	[mm]	[mm]	[mm]	
80,1					CMC-value?
85,3					☐ yes2
100,0					
		Date of calibration			
Micrometer 2		**Outside digital**	**25 - 50 mm**		
Calibration points	Used reference	Measured value	Stated correction	Stated measure-ment uncertainty	
[mm]	[mm]	[mm]	[mm]	[mm]	
27,5					
37,9					
50,0					
		Date of calibration			
Micrometer 3		**Tubular inside analog**	**50 - 75 mm**		
Calibration points		Measured value	Stated correction	Stated measure-ment uncertainty	
[mm]	[mm]	[mm]	[mm]	[mm]	
57,7					
67,6					
75					

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)
- ISO 3650:1998 Geometrical product specifications (GPS)-Length Standards-Gauge blocks
- ILAC-G8:09/2019 Guidelines on Decision Rules and Statements of Conformity