Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC) of the calibration in the length area – part 1 (gauge blocks)

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.

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 published on smquality.se 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

The following instruments are included:

Gauge blocks

- Gauge block, 1,26 mm
- Gauge block 50 mm
- Gauge block 80 mm

Micrometer, outside analog 75-100 mm

Micrometer outside digital 25-50mm

Tubular inside micrometer (2-point) 50-75 mm

Calliper outside analog 0-150 mm

Calliper outside digital 0-150 mm

Dial gauge indicator (analog) 0-10 mm (10 revolutions)

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 pilot 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:

• Gauge block 1,26 mm	length in the center and 4 corner points (see ISO 3650)
• Gauge block 50 mm	length in the center and 4 corner points (see ISO 3650)
• Gauge block 80 mm	length in the center and 4 corner points (see ISO 3650)
• 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,
• 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
• Dial gauge indicator	Range 10 mm (10 revolutions)
	Parameters: R, H, MPE 1/10 rev, ½ rev, 1 rev
	Parameters: R, H, MPE 1/10 rev, ½ rev, 1 rev

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 organiser received 20 excel files related to gauge blocks. 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 1 – on three gage blocks

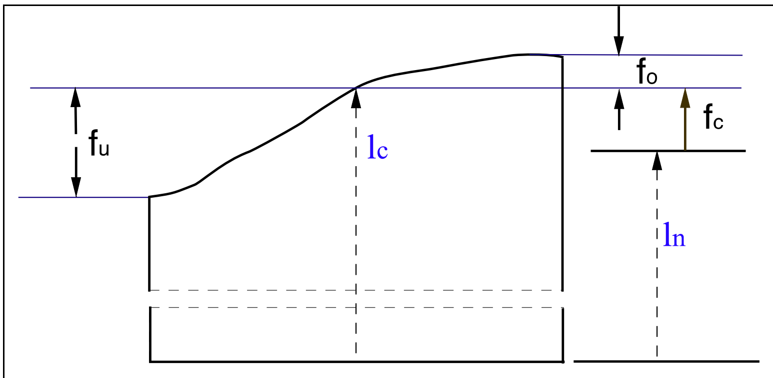
Considering 15 laboratories from four different countries of which four with several operators performing the calibration work the timeline could be kept quite well. The following up of eventual drift based on the excel protocols, however, was not as successful as planned. Firstly, some of them were 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. This is also the explanation for a late discovery that gauge block 2 incidentally got exchanged. Anyhow, the reference group then decided to issue the report on gage blocks first as part 1. Part 2 for micrometers, part 3 for calipers and finally part 4 for the dial gauge indicator will follow. They are a part of the same inter-comparison, but the results are reported separately

Analysis of the calibration results

In the instructions for the gage blocks 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 length in the centre and the difference to the corner points (1 to 4) defined by a drawing. The excel protocol was aimed to report the five measured lengths together with the used reference length. For most participants this did not work as intended. Probably there are several reasons for that. The apparatus used for comparison is different and perhaps most important thing that the process is automatized and thus only a reference value before applying correction was protocolled. Besides the reference laboratory only two Swedish participants explicitly supplied all four corner differences to the central length. All German laboratories followed the ISO 3650 product specification to report the maximum and minimum distance of the corner to the centre length. And this is even valid for the laboratories from Denmark and Finland.

The comparison thus is focused on mainly three measures (see drawing below). This is ***fc*** the difference between the calibrated centre length ***lc*** and its nominal value ***ln***. If ***lc*** > ***ln*** then ***fc*** is positive, otherwise ***fc*** is negative. In this context ***fc*,** the deviation from the gage blocks nominal value is also the correction which should be applied to the nominal value when using it as a length standard. (Thus ***-fc*** could be regarded as the gage block error). In the tables and diagrams below ***fc*** is the main calibration result compared. Instead of four corner deviations from the centre length ***lc*** only the distance ***fo*** to the corner with the largest length and ***fu*** the distance to the shortest length is listed; both are absolute values.



Definition of measures

ln: nominal length (1,26; 50 and 80 mm)
lc: actual calibrated centre length
fc: deviation of centre length from nominal length
fo: height difference from highest corner to centre
fu: height difference from lowest corner to centre

For a faster overview besides the found values fc_i for each participant *i* also the difference from the inter-comparison reference value fc_{ref} is displayed, which is the average between the results from the reference laboratory before and after the ILC.

Along with each result fc_i the tables also list the stated measurement U(fc_i) uncertainties stated by the participants. Together with the reference value fc_{ref} and its uncertainty U(fc_{ref}) found at the bottom line in the tables (R1&R2) the En-value is calculated.

$$En = \frac{|fc_i - fc_{ref}|}{\sqrt{U^2(fc_i) + U^2(fc_{ref})}}$$

For each calibrated point

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

fc_{ref}: Reference value for comparison – provided from reference laboratory.

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

U(fc_{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

For gage block 1 and 3 the result $\boldsymbol{fc_{ref}}(1)$ from the final calibration was 0,01 µm larger than for the first one $\boldsymbol{fc_{ref}}(2)$. As this difference is clearly below the stated uncertainty U(fc_{ref}) of 0,03 and 0,06 µm respectively, no drift was noticeable. As consequence, the inter-comparison reference value was chosen to

$$fc_{ref} = \frac{fc_{ref}(1) + fc_{ref}(2)}{2}$$

Concerning gage block 2, with 50 mm nominal length, this did not hold. This gage block seems to have been accidentally replaced during the circulation. Until calibration no 11 in series everything worked fine. Calibration no 12 and 13 unfortunately did not provide information on the gage block identity in the calibration certificates. First from calibration no 14 to 16 a new identity is clearly stated.

The advisory group decided to keep all collected results for gage block 2 and present them in this report. Some explanations about details follow in table 2 and diagram 2.

Due to these circumstances $\boldsymbol{fc_{ref}}(1)$ and $\boldsymbol{fc_{ref}}(2)$ from the reference laboratory were taken in the first and the second part respectively as reference value for the En-calculation. This does not influence the outcome as the fc_{ref} values only differ by 0,01 µm; however, it would seem dubious if one would treat two different objects as the same.

For a given gage block the reference laboratory provided the same uncertainty U(fc_{ref}) in both calibrations. The fact that a repeated measurement should lower the combined result is not used in this case. Firstly, the due to time elapsed measurement conditions might be slightly different, secondly the objects might have changed, which however was far below the stated uncertainty from the reference laboratory. As compromise the uncertainty of the inter-comparison reference value was set to

$$U(fc_{ref}) = U(fc_{ref}(1)) = U(fc_{ref}(2))$$

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.

- Gauge blocks: 105101-139547-K01 and 105101–139547-K08

Measuring results on calibration in the intercomparison-- gauge blocks

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 The lacking data from P5 means that this laboratory did not take part in the gage block calibration.

Table 1. Result for gage block no: 190566 - Random listing of results fc_i, $fc_i – fc_{ref}$, $U(fc_i)$ from participants

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value *fc - fc_{ref}*	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	1,26001	0,01	-0,005	0,03	-	0,01	0,02
P1	1,26003	0,03	0,015	0,07	**0,20**	0	0,03
P2	1,25999	0,000	-0,015	0,081	**-0,17**	0,01	0,02
P3	1,2599933	0,003	-0,012	0,091	**-0,12**	0,01	0,027
P4	1,26005	0,13	0,115	0,071	**1,49**	0,06	0,01
P5							
P6	1,26001	0,02	0,005	0,07	**0,07**	0,00	0,040
P7	1,26016	0,02	0,005	0,101	**0,05**	0,01	0,020
P8	1,26003	0,03	0,015	0,05	**0,26**	0,00	0,04
P9	0,000014	0,014	-0,001	0,05	**-0,02**	0,02	0,036
P10	1,25998	-0,02	-0,035	0,11	**-0,31**	0,01	0,01
P11	1,26006	0,06	0,045	0,111	**0,39**	0,02	0,03
P12	1,26005	0,05	0,035	0,06	**0,52**	0,01	0,04
P13	1,26013	0,12	0,105	0,10	**1,01**	0,00	0,08
P14	1,26002	0,02	0,005	0,05	**0,08**	0,01	0,03
P15	1,2601	0,06	0,045	0,40	**0,11**	0,00	0,20
R2	1,26002	0,02	0,005	0,03	-	0,01	0,03
R1&R2	*fc_{ref}*:	**0,015**	U(*fc_{ref}*):	**0,03**			

Comment: R1 and R2 stand for the two reference calibration results. The last line (R1&R2) specifies the intercomparison reference value being their average.

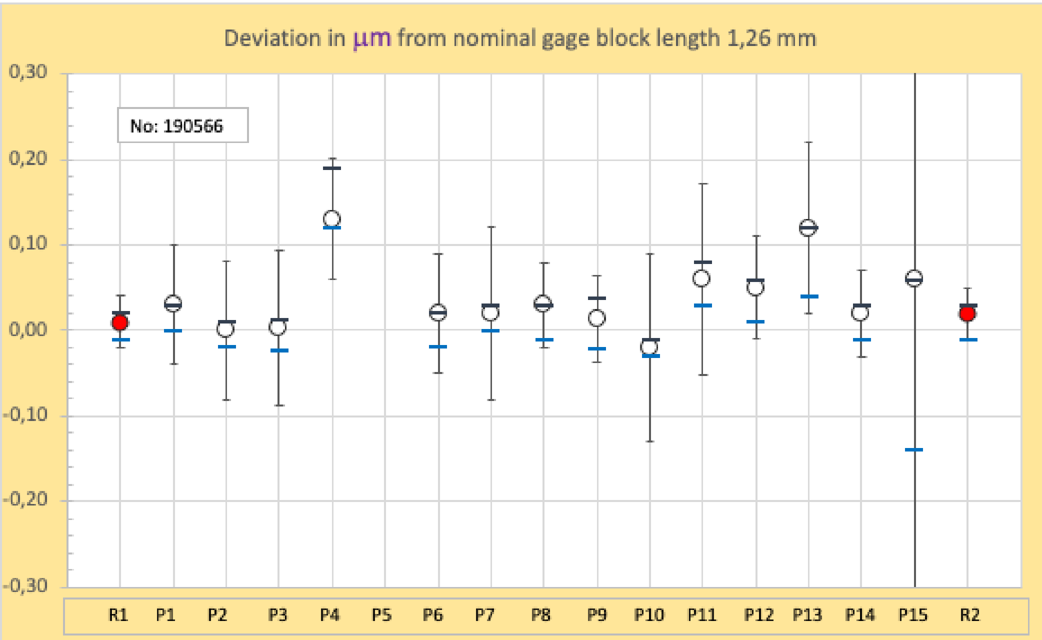


Diagram 1. Red circles result *fc* from the reference laboratory. Black bars indicate the maximum length *fc*+*fo*, blue bars represent minimum length *fc – fu* of the gage block together with the reported uncertainty.

Table 2. Results for gage block 2 two different objects no: 201665 and no: 49730

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value *fc - fc_{ref}*	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	50,00008	**0,08**	*0*	**0,04**	-	0,01	0,04
P1	50,00009	0,09	*0,01*	0,08	**0,11**	0,00	0,04
P2	50,00006	0,05	*-0,03*	0,12	**-0,24**	0,01	0,02
P3	50,00003	0,063	*-0,017*	0,12	**-0,13**	0,00	0,06
P6	50,00012	0,05	*-0,03*	0,12	**-0,24**	0,00	0,02
P7	50,00012	0,09	*0,01*	0,15	**0,06**	0,00	0,05
P8	50,00005	0,05	*-0,03*	0,07	**-0,37**	0,01	0,02
P9	0,000028	0,028	*-0,052*	0,069	**-0,65**	0,00	0,05
P11	50,00005	0,05	*-0,03*	0,145	**-0,20**	0,00	0,04
P14	50,00002	0,02	*-0,06*	0,075	**-0,71**	0,00	0,04
P5							
P4	50,00010	-0,07	*-0,16*	0,112	**-1,35**	0,00	0,07
P10	50,00006	0,06	*-0,03*	0,121	**-0,24**	0,00	0,05
P12	50,00012	0,12	*0,03*	0,08	**0,34**	0,03	0,08
P13	50,00015	0,15	*0,06*	0,100	**0,56**	0,00	0,07
P15	50,00030	0,14	*0,05*	0,4	**0,12**	0,00	0,30
R2	50,00009	**0,09**	*0*	**0,04**	-	0,00	0,07

Comment: Due to the exchange of the 50 mm gage block table2 and diagram 2 were divided in two sections. In the upper part all numbers are in black whereas they are blue in the lower part. For the En-calculation of the first (black) results the reference value R1 on the top, for the second (blue) the reference value R2 at the bottom was used.

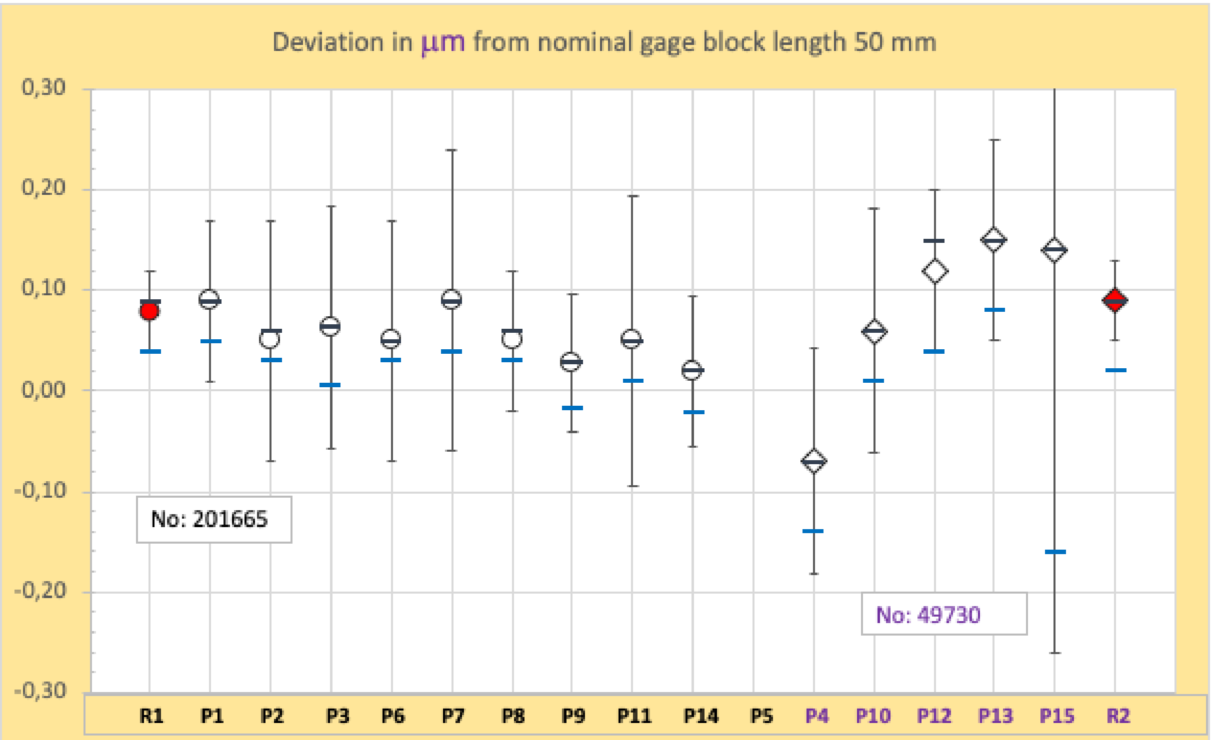


Diagram 2. The circles to the left concern the original 50 mm gauge block. For results for the exchanged one are given with rhombs to the right

Table 3. Results for gage block 3 no: 200512

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value *fc - fc_{ref}*	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	80,00015	0,15	-0,005	0,06	-	0,00	0,05
P1	80,00018	0,18	0,025	0,10	**0,21**	0,00	0,07
P2	80,00012	0,09	-0,065	0,144	**-0,42**	0,00	0,05
P3	80,0000933	0,183	0,028	0,138	**0,19**	0,00	0,07
P4	80,00025	0,49	0,335	0,137	**2,24**	0,00	0,07
P5							
P6	80,00025	0,13	-0,025	0,16	**-0,15**	0,00	0,06
P7	80,00003	0,20	0,045	0,18	**0,24**	0,00	0,13
P8	80,00017	0,17	0,015	0,11	**0,12**	0,01	0,04
P9	0,000124	0,124	-0,031	0,08	**-0,31**	0,00	0,07
P10	80,00018	0,18	0,025	0,136	**0,17**	0,00	0,07
P11	80,00018	0,18	0,025	0,166	**0,14**	0,00	0,05
P12	80,00019	0,19	0,035	0,12	**0,26**	0,01	0,07
P13	80,00008	0,16	0,005	0,10	**0,04**	0,00	0,09
P14	80,00011	0,11	-0,045	0,09	**-0,42**	0,00	0,06
P15	80,0004	0,08	-0,075	0,60	**-0,12**	0,00	0,20
R2	80,00016	0,16	0,005	0,06	-	0,00	0,06
R1&R2	*fc_{ref}*:	**0,155**	U(*fc_{ref}*):	**0,06**			

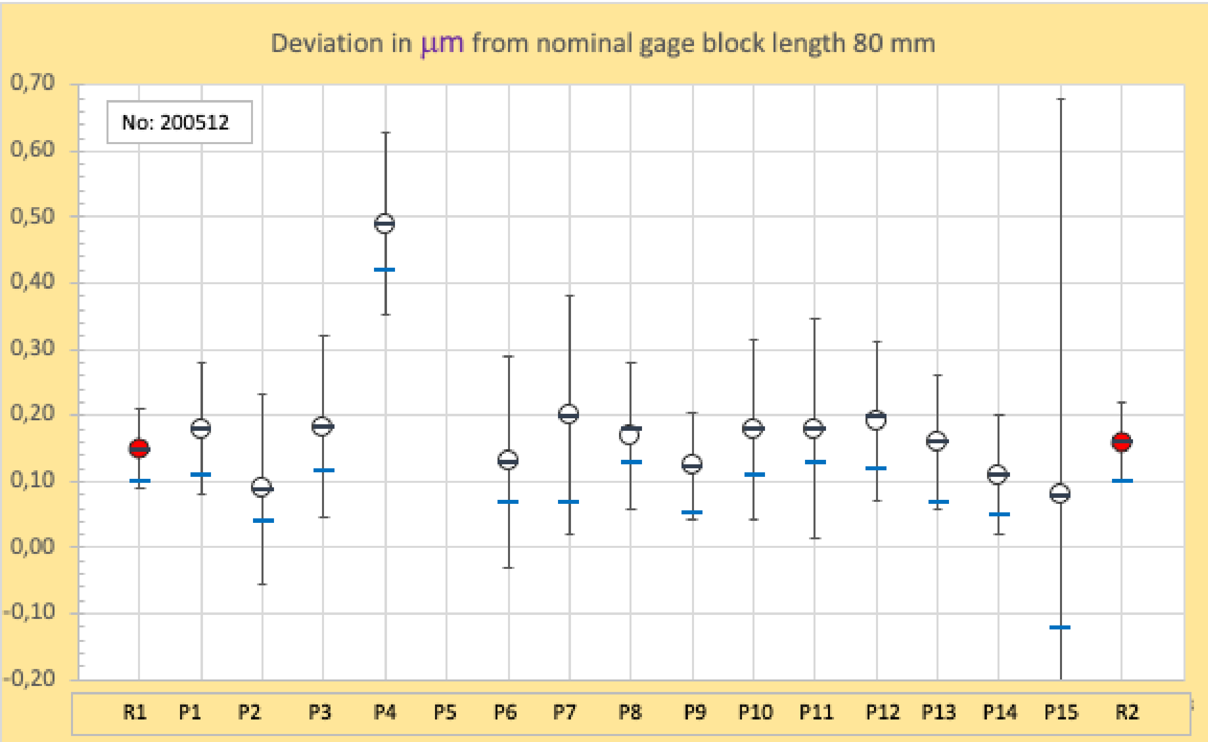


Diagram 3. Found correction for the center length of gage block 3, which also is identical with the largest length, as all but two participants found *fo* = 0, i.e. no corner length is larger.

Comments:
In most cases the explicit stated result for ***fc, fo*** and ***fu*** in the calibration certificates could also be derived from the excel protocols. However, for some participants this derivation was only close, i.e. within ±0,01 µm, dependent on the way the protocol was filled out and if it reported just one value or an average from several measurements. However, the tables always give back the measures ***fc, fo*** and ***fu*** as stated in the corresponding certificates. Two participants did not provide a calibration certificate, eventually because they did not yet have an accreditation. In this case the table values are analyzed only based on the excel-protocol data.

The German laboratories stated their measurement uncertainties in form of an equation dependent on gage block length. This is also the reason that the tables display a higher resolution in some cases. Most other participants gave fixed numbers for certain length ranges. If an uncertainty figure differed between the excel-protocol and the certificate always the later were used.

Evaluation of results in different corners

The original ambition was to report a comparison for the gauge block centre and for each corner separately. This, however, could not be evaluated in a satisfactory way. Only two laboratories except the reference laboratory did specify the difference between the centre length and the four corner points in their certificate. In annex 4 it is tried at least for gage block 1 to give an idea how the participants judged the corner results with respect to the centre.

Additional calibration results

Altogether 14 of 15 participants calibrated the three gage blocks. But among those 14 laboratories different persons from the staff repeated the calibration on these objects; thus, two results were reported from participant P6, three from participant P7, two from participant P15 and P10. To keep a straight report giving all laboratories the same attention those extra results are collected in separate tables and diagram below. Whereas the data from the reference laboratory and from participants P6, P7, P10 and P15 are identical with those from the tables 1 to 3 the rest comes from different people in those laboratories. The idea was to qualify those persons work under the same circumstances. That means these results including the En-values are directly comparable to the previous tables and diagrams.

Table 1-2: Result for gage block 1 No: 190566 from other personnel from participants P6, P7, P10 and P15

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value $fc - fc_{ref}$	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	1,26001	0,01	-0,005	0,03	-	0,01	0,02
P6	1,26001	0,02	0,005	0,07	**0,07**	0,00	0,040
P6-2	1,26001	0,02	0,005	0,07	**-0,74**	0,00	0,06
P7	1,26016	0,02	0,005	0,101	**0,05**	0,01	0,020
P7-2	1,26006	0,01	-0,005	0,101	**-0,05**	0,01	0,020
P7-3							
P7-4	1,26006	0,01	-0,005	0,101	**-0,05**	0,01	0,020
P15	1,2601	0,06	0,045	0,40	**0,11**	0,00	0,20
P15-2	1,26	-0,06	-0,075	0,40	**-0,19**	0,00	0,20
P10	1,25998	-0,02	-0,035	0,11	**-0,31**	0,01	0,01
P10-2	1,25998	0	-0,015	0,11	**-0,13**	0,01	0,01
R2	1,26002	0,02	0,005	0,03		0,01	0,03
R1&R2	fc_{ref}:	**0,015**	U(fc_{ref}):	**0,03**			

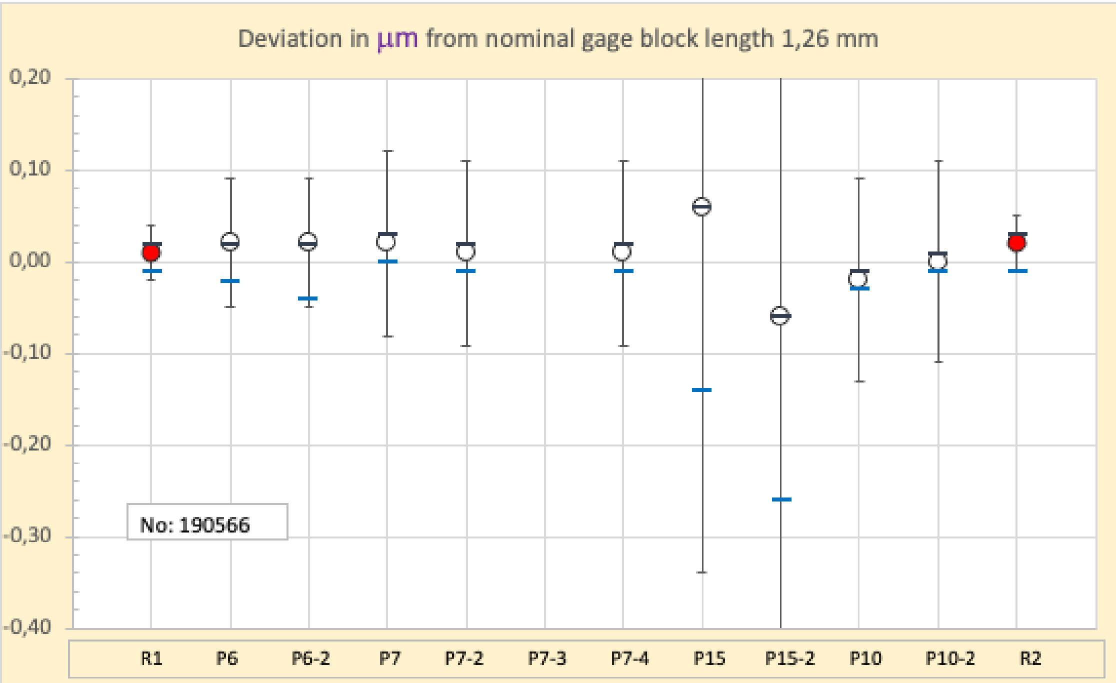


Diagram 1-2: For participant P7-3 results were there reported for all other objects but not for the gage blocks

Table 2-2: Result for gage block 2 No: 201665 and 49730

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value *fc - fc ref*	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	50,00008	**0,08**	0	**0,04**	-	0,01	0,04
P6	50,00012	0,05	-0,03	0,12	**-0,24**	0,00	0,02
P6-2	50,00004	-0,03	-0,11	0,12	**-0,87**	0,01	0,01
P7	50,0001	0,09	0,01	0,15	**0,06**	0,00	0,05
P7-2	50,00068	0,06	-0,02	0,15	**-0,13**	0,00	0,06
P7-3							
P7-4	50,00045	0,06	-0,02	0,15	**-0,13**	0,00	0,06
P15	50,00030	0,14	0,05	0,4	**0,12**	0,00	0,30
P15-2	50,00030	0,16	0,07	0,4	**0,17**	0,10	0,30
P10	50,00006	0,06	-0,03	0,12	**-0,24**	0,00	0,05
P10-2	50,00008	0,11	0,02	0,12	**0,16**	0,01	0,04
R2	50,00009	**0,09**	0	**0,04**	-	0,00	0,07

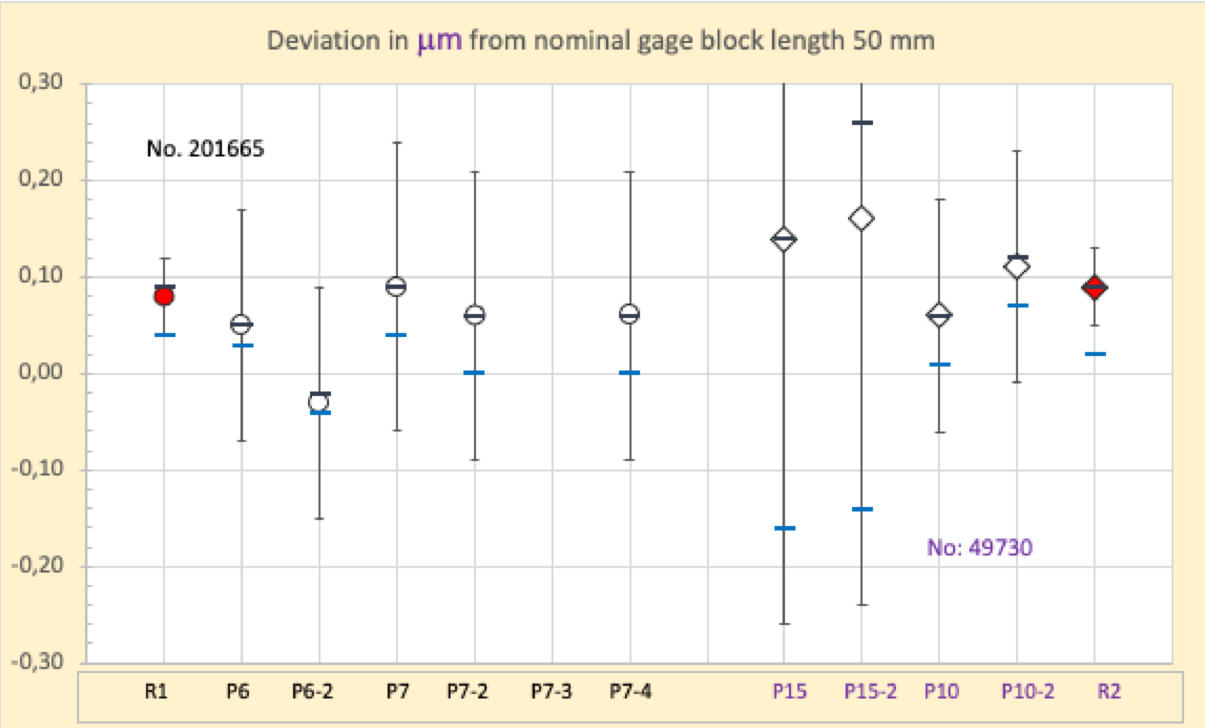


Diagram 2-2: The results on the exchanged object to the right are separated and indicated by a different symbol.

Table 3-2: Additional result for gage block 3 No: 201665 from participants P6, P7, P10 and P15

Participant	Measured value *lc*	Deviation from nominal value *fc*	Difference to reference value *fc - fc ref*	Measurement uncertainty U(*fc*)	En-value	*fo*	*fu*
	mm	µm	µm	µm		µm	µm
R1	80,00015	0,15	-0,005	0,06	-	0,00	0,05
P6	80,00025	0,13	-0,025	0,16	**-0,15**	0,00	0,06
P6-2	80,00019	0,00	-0,155	0,16	**-0,91**	0,06	0,06
P7	80,00003	0,20	0,045	0,18	**0,24**	0,00	0,13
P7-2	80,00064	0,19	0,035	0,18	**0,18**	0,00	0,11
P7-3			-0,155				
P7-4	80,00062	0,19	0,035	0,15	**0,22**	0,00	0,11
P15	80,0004	0,08	-0,075	0,60	**-0,12**	0,00	0,20
P15-2	80,0002	-0,10	-0,255	0,60	**-0,42**	0,00	0,40
P10	80,00018	0,18	0,025	0,136	**0,17**	0,00	0,07
P10-2	80,00016	0,02	-0,135	0,140	**-0,89**	0,00	0,08
R2	80,00016	0,16	0,005	0,06	-	0,00	0,06
R1&R2	*fc ref*:	**0,16**	U(*fc ref*):	**0,06**			

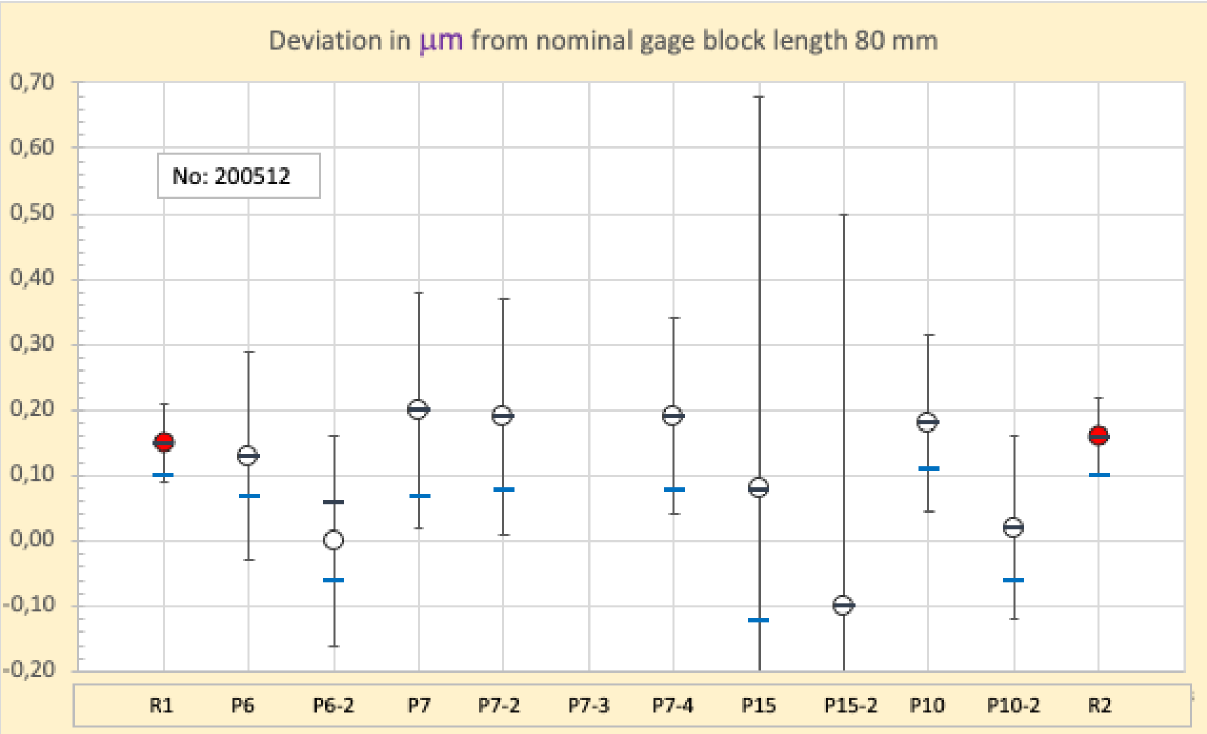


Diagram 3-2: Results marked with -2 and -4 are additional to those in diagram 3.

Comments on calibration certificates

-not a part of the intercomparison

General

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 have an accreditation from the local accreditation institutes except for the case of the tubular micrometer where most of the laboratories do not refer to an accreditation.

Many of the German laboratories use the same design of the calibration certificates.

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. Some laboratories indicate the actual temperature during calibration very clear (e.g., ±0,6 per hour). Some laboratories are describing the time they use for temperature stabilization (e.g., 6 hours). Length expansion component is sometimes documented as well as the surface temperature.

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.

Comments on the calibration certificates on gauge blocks

Several laboratories refer to and describe tolerances according to ISO 3650.

Pictures of situation for different corners of the gauge blocks are defined in some cases in the certificates but it is not clear in other cases.

Some laboratories give the absolute value in µm and others the difference from the nominal value for the corners.

Many of the laboratories describe the uncertainty using a formula, based on a fixed value and the length, other laboratories give the uncertainty value on the calibrated point. Some laboratories also specify a lower uncertainty for the difference of to the corners to the center.

Some laboratories list tables on different grades of gauge blocks and specify if the gauge blocks fulfil the requirements.

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 gauge blocks 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 57 En-values were calculated with only 4 values higher than 1.

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							**Evaluation part**			Definitioner:	
Laboratory:	Pilot Rise			Comparison ID	**R2**					lc = uppmätt central längd so	
Name:	Peter Lau						This part is decided if both sides are filled in			fc = Skillnaden mellan uppmä	
e-mail:							Conveting to tables and diagrams			fo = Skillnad mellan största h	
Reporting date:	2021-11-01									fu = Skillnad mellan centralm	
3 Gage blocks											
		Date of calibratio	2021-10-18								
Gauge block 1		**Nominal value**	**1,26 mm**				**To evaluation**		**From certificate**	105101-139547-K18	
Calibration point	Reference gauge value	Measured value	Stated correction	Stated measure-ment uncertainty	Number of repetitions		Determind correc-tion for comparison	Determined uncertainty	Stated correction	Expanded uncertainty	Nr 190566
	[mm]	[mm]	[µm]	[µm]			[µm]	[µm]	[µm]	[µm]	
Center	1,26000	1,26002	0,02	0,03	CMC-value?	fc	0,02	0,03	0,02	0,03	
Point 1	1,26000	1,26001	0,01	0,05	☐ yes1	fo	0,01	0,05	0,01	0,05	
Point 2	1,26000	1,26003	0,03	0,05		fu	0,03	0,05	0,03	0,05	
Point 3	1,26000	1,26000	0	0,05		v	0,04		0,00	0,05	
Point 4	1,26000	1,25999	-0,01	0,05					-0,01	0,05	
		Date of calibratio	2021-10-18								
Gauge block 2		**Nominal value**	**50 mm**						**From certificate**	105101-139547-K15	
Calibration point	Reference gauge value	Measured value	Stated correction	Stated measure-ment uncertainty			Determind correc-tion for comparison	Determined uncertainty	Stated correction	Expanded uncertainty	Nr 49730
[mm]	[mm]	[mm]	[µm]	[µm]			[µm]	[µm]	[µm]	[µm]	
Center	50,00000	50,00009	0,09	0,04		fc	0,09	0,04	0,09	0,04	
Point 1	50,00000	50,00002	0,02	0,06		fo	0	0,06	0,02	0,06	

Annex 4 evaluation of different corners

To reveal how consistent the participants were in determining the relation between the centre and the corner points the provided excel-data was used to produce the table below. This might not be perfectly correct thinking of the way the protocol form was used. However, it gives a quite good impression which corner is considered to have the maximum and which the minimum length.

Table 4. Corner identification of gage block 1 1,26 mm

	Max				Min
R1	2	C		1 ; 3	4
P1	2 ' C		3	4	1
P2	1 ' 2 ' 4			C	3
P3	2	3	C	4	1
P4	1	3	2	C	4
P6	C	2	1 ' 4		3
P7	2	C	1 ' 3		4
P8	2 ' C		3	4	1
P9	2	C	3	4	1
P10	2	C			1 ' 3 ' 4
P11	2	C	1	3	4
P12	2 ' 3	C		4	1
P13	C	4	1	2	3
P14	2	C	3	4	1
P15	C	3	1 ' 2 ' 4		
R2	2	C	1	3	4

Explanation:
The numbers 2 to 4 represent the four corner points and C the centre.
Point 2 is considered the maximum 11 times; three times the centre is pointed out as single maximum; four results do not state one clear maximum.
In eight cases the centre C represents the second largest length; three times corner point 3 holds this place.
A "middle length" is attributed to all points.
The second shortest length is mainly ascribed to corner point 4
Equally often the minimum length is appointed to corner point 1 and 4.

Given the limited validity of several excel-protocols one can see that there is no total agreement how the gauge block corners were determined with respect to the centre. However, the qualitative judgement is reasonable concerning the reported measurement uncertainties.

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