Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC 2021:2) of the calibration in the length area – part 2 (micrometres and callipers)

The case carrying all equipment for calibration.

Weight 20 kg

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Calculations

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Content

Abstract

The intercomparison ILC length 2021:2 included 4-gauge blocks, 2 control rods, a two-point micrometre and a calliper. The results are presented in 2 reports. This report is number 2 covering the comparison for the two-point inside micrometre and the calliper.

The number of participating laboratories in this intercomparison was 12, but 13 results are reported as one laboratory presented results from calibrations made by 2 calibration technicians.

It was recognized during the intercomparison that the digital calliper remained very stable during the circulation.

The opposite applies for the micrometre where the mean value and its uncertainty were affected seriously, which reduces the quality of that part of the intercomparison, i.e. the reliability of the calculated En-values.

The number of calibration points in total for all objects was 54. For the micrometre 8 En-values were larger than 1 for the calliper it was 5.

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 2021:2 intercomparison as well as the choice of measuring points 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

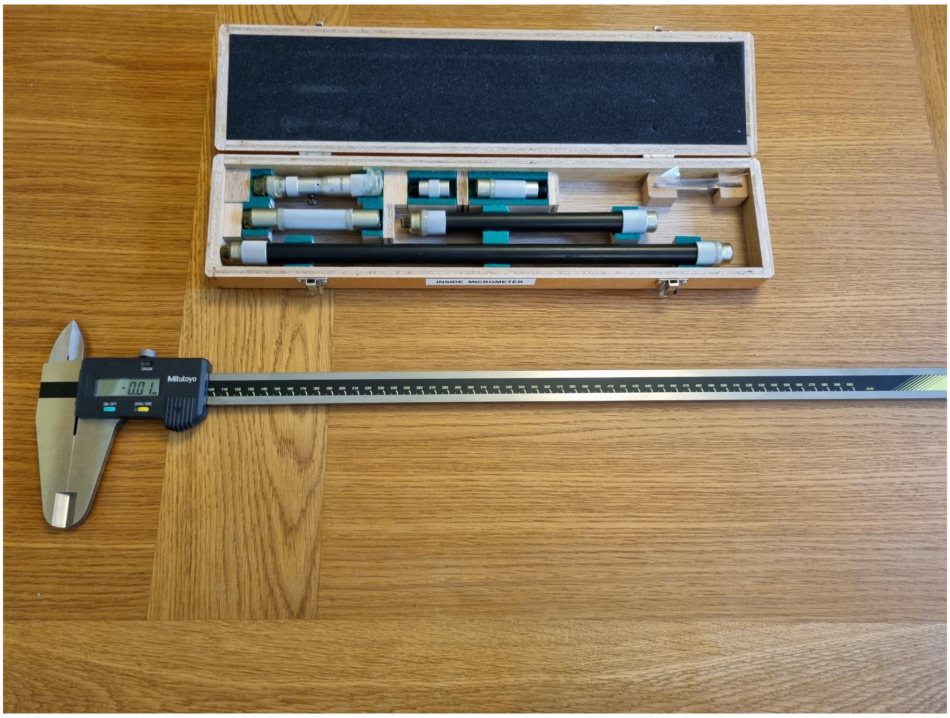
The information about the intercomparison was given in 3 different media:

- 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.

Involved equipment.



Inside micrometre and calliper

Participating laboratories and measuring scheme for the comparison

Laboratory	Delivery address
MIKES Metrology, VTT Length Metrology Technical Research Centre of Finland	Tekniikantie 1, FI-02150 ESPOO, Finland **Reference laboratory**
Koneteknologiakeskus Turku OY	Lemminkäisenkatu 28, 20520 Turku, Finland
SKF Sverige AB	Kvibergs Broväg 8, SF-Terminal 1/Mätcentrum, 415505 Göte-borg, Sweden
Element Metech AB	Flygmotorvägen 1, SE-461 38 Trollhättan Sweden
Element Metech KDK GmbH	In den Ziegelwiesen 25 DE-69186 Wiesloch Germany
TÜV NORD Mobilität GmbH & Co. KG	Frillendorferstrasse 137 45139 Essen, Germany
Hainaut Analyses	4ème Rue, N°13 6040 JUMET Belgique
METROMAT SRL	Str. Ady Endre nr. 44 Sacele jud Brasov 505600 Romania
KIWA CERMET ITALIA SPA	Via Cadriano 23 40057 Granarolo (BO) Italy
MeßTechteknikNord GmbH	Industriestarße 29 22880 Wedel Germany
SC Nuclear NDT Research and services SRL	Soseanua Berceni, Nr 104 Cladirea Laborator Central, Sector 4 Bucharest, Romania
Janz-contagem e Gestao de Fluidos,SA	Av Infante D 288 1950-421 Lisboa Portugal
Elastocon AB	Tvinnargartan 25, 507 30 Brämhult Sweden

A majority performed a calibration on all equipment others only some objects. During the exercise all together 57 calibrations on different points were performed.

Most of the participants have an accreditation by SWEDAC, DANAK, FINAS, DAkkS. BELAC, RO-MANIA RENAR, ACCREDIA or IPAC.

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 performed a second calibration after the last participant calibration.

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 and if necessary to do a reference calibration if necessary.

Conditions and transport during the measurement period

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

Calibration instructions

The laboratories were allowed maximum 10 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:

- Micrometre 100, 500 and 600 mm
- Calliper 100, 400 and 600 mm

The participants were 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 administrative details

The laboratories were asked to send original calibration data in pre-defined protocols (enclosed in annex 3) in digital form as excel files by e-mail before issuing transportation to the next laboratory.

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:

- A preliminary result should be sent to the organiser before the parcel was sent to the next participant.
- One week after the calibration/measurement the calibration certificate should be send to the evaluator of the intercomparison.
- A draft report should be distributed to the participants two weeks after receiving the last calibration certificate.
- Comments on the draft report to the organiser were asked to be received within one week.
- The final report should be finalized within two weeks after receiving comments from all participants.

Report part 2–Results on micrometres and callipers

Analysis of the calibration results

Every participant should follow its own method to perform the calibration and the calibration certificate should be presented as if it were to a usual customer.

The information asked for comparison was the results – indication error / deviation from nominal value - for the micrometre and the calliper including three obligatory measuring points for each instrument. Each of these error values e_i are compared to a corresponding reference value e_{ref} defined by the average error indication supplied by the National Metrology Institute VTT MIKES, FINLAND, who calibrated the instruments before and after the intercomparison exercise.

The reason for using the term error /deviation is that most of the laboratories as well as the reference laboratory used it in their calibration certificates.

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

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

Equation 1

For each calibrated point

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

e_{ref}: Corresponding 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

Both the reference error e_{ref} and its uncertainty U_{ref} are composed from two calibrations

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 absolute value of 1.

Inter-comparison reference value and uncertainty

Reference calibrations were performed by VTT MIKES before and after the circulation and gives the base for evaluation as described.

The inter-comparison reference values for all measurement points and their belonging uncertainties were calculated as

$$e_{ref} = \frac{e_{ref}(1)+e_{ref}(2)}{2} \quad \text{and} \quad U_{ref} = \frac{\sqrt{U^2(1)+U^2(2)}}{\sqrt{2}} + \left|\frac{e_{ref}(1)-e_{ref}(2)}{2}\right|$$

(1) and (2) here refer to the starting and finishing calibration respectively.

Equation 2 and 3

Traceability for the reference values R1 and R2 at each point

The traceability for the reference laboratory the National Metrology Institute VTT MIKES, FINLAND is established by regular calibrations of the laboratory standards traceable to the realisation of the metre at VTT MIKES.

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

Micrometre	M-22L187 and M-23L082
Calliper	M-22L186 and M-23L080

Results for two-point inside micrometre

The following three tables and diagrams present the comparison outcome for the two-point micrometre instrument. From the difference between the two reference calibrations before and after the round robin it became clear that a considerable drift did happen, possibly caused by handling. As a matter of fact, the change over time was several times the stated uncertainty by the reference laboratory Mikes. By looking to all data, it is difficult to see a sudden change, but it is also hard to derive a trendline over time. As best solution therefore it was decided to simply use the average from both calibrations as was done for the other instruments as well and again add half the difference to the calibration uncertainty. This does, however, drastically enlarge the reference uncertainty for the micrometre instrument. Therefore, this reduces all En-values compared to the original calibration uncertainty. For participant results having a large uncertainty this has little effect. For those with low uncertainty the calculated En-values may not be as reliable as expected before the start of this comparison.

The participants are listed in the tables with an arbitrary identity from P1 to P13 which however is not in time order. This identity is kept the same throughout this ILC.

Table 1. Measurement point no 1: 100 mm.

Partici-pant	Measured value [µm]	Indication Error [µm]	Uncertainty [µm]	En-value
P1	100,0097	9,7	4	0,58
P3	100,0042	4	1,5	-0,66
P4	100,002	2	2,4	-1,06
P5	100,006	6	6	-0,08
P6	100	0	13	-0,49
P7	100,0079	7,9	2	0,32
P9	100,0012	1,2	2,4	-1,24
P10	99,997	-3	5,2	-1,51
P13	100,002	2	4,5	-0,79
R1&R2	100,006575	6,57	3,6	

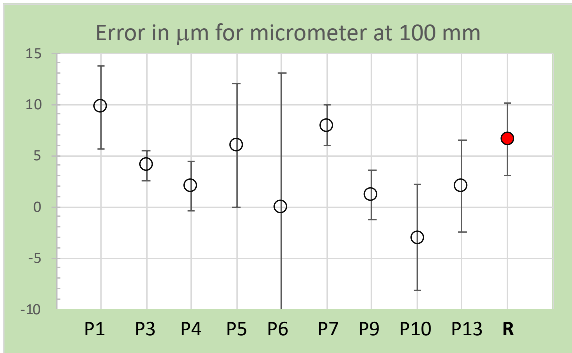


Diagram 1. Presenting the comparison result in form of indication error with the belonging uncertainties.

Column 2 stated the measured length read of the instrument. Column 3 displays the deviation between this object length and the used reference. Column 4 lists the stated measurement uncertainties. At the bottom of the table the belonging reference value is given with its corresponding uncertainty. Due to the drift, it is much larger than the reported one by the reference laboratory for either calibration. The last column contains the calculated En-values. These are in most cases favourable for participants especially for results with low uncertainty claims.

Table 2. Measurement point no 2: 500 mm.

Partici-pant	Measured value	Indication Error	Uncertainty	En-value
	[µm]	[µm]	[µm]	
P1	500,0033	3,3	8	-1,00
P3	500,0105	10	3,5	-0,39
P4	500,0027	2,7	7,2	-1,17
P5	500,009	9	6	-0,42
P6	499,996	-4	13	-1,18
P7	500,0086	8,6	2,1	-0,88
P9	500,0019	1,9	7,2	-1,27
P10				
P13	500,006	6	4,5	-1,07
R1&R2	500,01181	11,8	3,0	

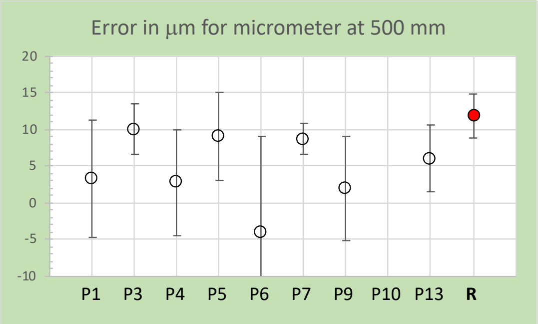


Diagram 2. Reference value in different colour signed only with R.

Comment: An empty line implies that participant P10 only reported one calibration result for 100 mm and participant 5 stopped at 500 mm.

Table 3. Measurement point no 3: 600 mm.

Partici-pant	Measured value	Indication Error	Uncertainty	En-value
	[µm]	[µm]	[µm]	
P1	600,0051	5,1	9	-0,39
P3	600,0088	9,0	4	0,02
P4	600,0039	3,9	9,5	-0,49
P5				
P6	600,002	2	13	-0,51
P7	600,0105	10,5	2,2	0,38
P9	600,003	3	9,5	-0,58
P10				
P13	600,006	6	4,5	-0,50
R1&R2	600,00890	8,9	3,6	

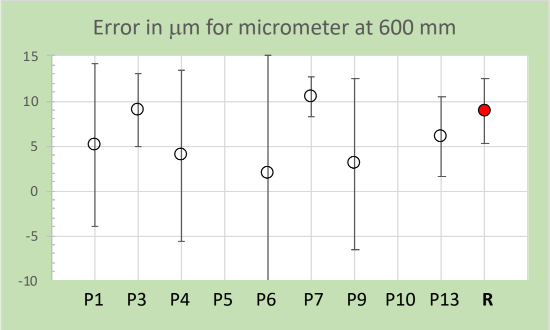


Diagram 3. For this situation most of the En-values are credible because participant uncertainty is increased.

Results for outside digital calliper

For this instrument both calibrations by the reference laboratory gave the same results. Thus, no drift did enlarge the reference uncertainty.

Table 4 Measurement point no 1: 100 mm.

Partici-pant	Measured value	Indication Error	Uncertainty	En-value
	[µm]	[µm]	[µm]	
P1	99,99	-10	33	0,26
P2	100,00	0	90	0,22
P3	99,99	0	6,5	0,95
P4	100,00	0	18	0,74
P5	99,99	-10	9	0,46
P6	99,99	-10	31	0,27
P7	99,99	-10	20	0,35
P9	100,00	0	18	0,74
P11	99,99	-10	53	0,18
P12	100,00	0	43	0,42
R1&R2	99,98	-20	20	

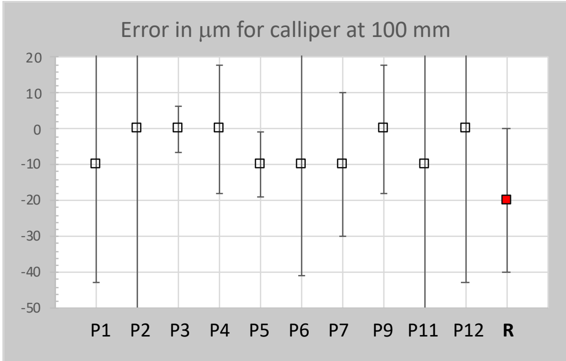


Diagram 4. A very good consensus is seen with a spread caused mainly by instrument resolution.

Table 5 Measurement point No 2: 400 mm.

Partici-pant	Measured value	Indication Error	Uncertainty	En-value
	[µm]	[µm]	[µm]	
P1	399,98	-20	42	0,43
P2	399,98	-20	90	0,22
P3	399,99	-10	8	1,39
P4	400,00	0	20	1,41
P5	399,98	-20	9	0,91
P6	399,96	-40	31	0,00
P7	399,98	-20	22	0,67
P9	400,00	0	20	1,41
P11	399,99	-10	62	0,46
P12	401,40	0	55	0,68
R1&R2	399,96	-40	20	

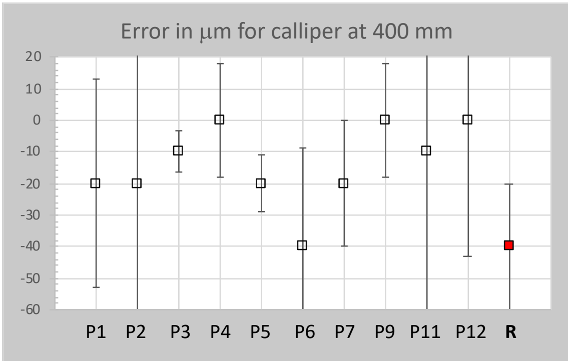


Diagram 5. Increasing spread in results, all reported error values lower than the reference.

Table 6 Measurement point No 3: 600 mm.

Partici-pant	Measured value	Indication Error	Uncertainty	En-value
	[µm]	[µm]	[µm]	
P1	599,97	-30	68	0,14
P2	599,97	-30	90	0,11
P3	599,99	0	9	1,82
P4	600,00	0	23	1,31
P5	599,97	-30	9	0,46
P6	599,95	-50	31	-0,27
P7	599,97	-30	24	0,32
P9	600,00	0	50	0,74
P11	599,97	-30	68	0,14
P12	600,00	0	62	0,61
R1&R2	599,96	-40	20	

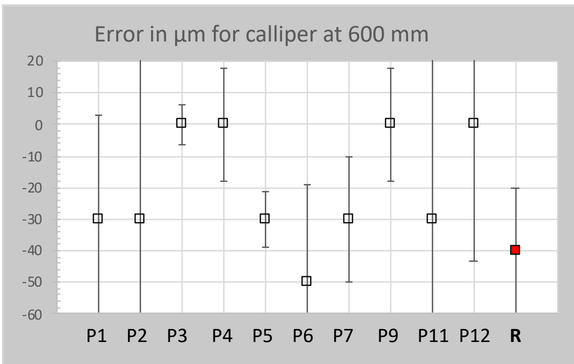


Diagram 6. All three diagrams reveal the same pattern but enlarged with increasing length.

Comment: Some of the claimed uncertainties simply seem too low to be realistic despite a good En-result.

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.

One participant presented the result as "deviation" but not between reference and object reading or vice versa. Instead, a deviation between the object and a "nominal value to which a possible deviation was added". Perhaps the idea was to refer to *a corrected reference*. For an ordinary customer this is probably hard to understand and leave him to guess whether he should add or subtract this deviation in using the calliper.

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.

Additions and changes to the DRAFT report part 1 and 2

Unlike instruments being able to display measurement values over a certain range gage blocks and setting rods have (like weights) only a single value. And in contrast to other instruments, they are characterized by a nominal value and a deviation from it, which to specify is the task of a calibration. One can call this deviation an error. However, when using the calibrated gage block this deviation is added to the nominal value. One could therefore say this deviation (error) is the correction that should be applied to use the gage block as a reference in the correct way. (This contrasts with other instruments where the calibrated measurement error and the applied correction have opposite sign).

These circumstances were difficult to interpret in the participants various calibrations certificates. It also generated complications between the results given in the excel-protocol and some certificates. The organizer therefore changed the view and uses in this final report the deviation from the nominal value as the result for comparison between the participants. Therefore, all En-values change sing. This also applies to the two-point micrometre and the calliper in this second report.

In some cases where there was a difference between a reported deviation in the excel-protocol compared to the one stated in the certificate the later one was used, which changed some En-values to lower or higher (absolute) values.

Final conclusions

In this inter comparison most of the participants could demonstrate capacity to calibrate the micrometres and callipers that are involved in this ILC. Most of the laboratories took part in the comparison of all equipment.

The number of calibrated points in total for both instruments was 54 and En-values of 1 or higher was for inside micrometre are 8 and for the calliper 5.

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, Quality Control in Metrology Sweden as well as the main evaluator of the results Peter Lau MNE-Konsult AB

We also acknowledge the primary calibrations by VTT MIKES, FINLAND 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.

Inter-comparison ILC length 2021:2 Code for opening the transportation case: 504

Reporting form for preliminary calibration results

Laboratory:		Comparison ID	
Name:			
e-mail:			
Reporting date:			

Utvärderingsdel

Denna del bestäms när båda sidor är klara
Mellandelen förvandlas till tabelle och
diagram

OBSERVE that no adjustments are allowed except zeroing

4 Gage blocks small and large size **Date of calibration**

Gauge block 1 **Serial no. 215272**

Calibration point	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for comparison	Determined uncertainty	Stated correction (From certificate)	Expanded uncertainty (From certificate)
	[mm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]
Center	2							
Corner point 1	2							
Corner point 2	2							
Corner point 3	2							
Corner point 4	2							

Gauge block 2 **Serial no. 213099**

Calibration point	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for comparison	Determined uncertainty	Stated correction (From certificate)	Expanded uncertainty (From certificate)
[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]
Center	50							
Point 1	50							
Point 2	50							
Point 3	50							
Point 4	50							

Gauge block 3 **200 mm** **Serial no. 210512**

Calibration point	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	correc-tion for comparison	Determined uncertainty	Stated correction (From certificate)	Expanded uncertainty (From certificate)
[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]
Center								

Gauge block 4 **600 mm** **Serial no. 220006**

Calibration point	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for	Determined uncertainty	Stated correction (From certificate)	Expanded uncertainty (From certificate)
[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]	[µm]
Center								

Micrometer setting rod 1 **Serial no. 2000184**

Calibration point	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for comparison	Determined uncertainty	Stated correction	Expanded uncertainty
[mm]	[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[mm]	[mm]
100								

Micrometer setting rod 2 **Serial no. 2022215**

Calibration points	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for	Determined uncertainty	Stated correction	Expanded uncertainty
[mm]	[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[mm]	[mm]
500								

Inside two-point-micromet **Serial no. 72398800**

Calibration points	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	correc-tion for comparison	Determined uncertainty	Stated correction	Expanded uncertainty
	[mm]	[mm]	[µm]	[µm]	[µm]	[µm]	[mm]	[mm]
100 mm								
500 mm								
600 mm								

Outside digital caliper **Serial no. 81348**

Calibration points	Nominal length	Measured length	Error (deviation from nominal)	Stated measure-ment uncertainty	Determind correc-tion for comparison	Determined uncertainty	Stated correction	Expanded uncertainty
	[mm]	[mm]	[mm]	[mm]	[mm]	[µm]	[mm]	[mm]
100 mm	100							
400 mm	400							
600 mm	600							

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