



SHORT GAUGE BLOCKS

INTERLABORATORY COMPARISON

APLAC M018 - December 2007

ACKNOWLEDGMENT

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1. INTRODUCTION

This report summarizes the results of an interlaboratory comparison on Short Gauge Blocks calibration by laboratories accredited by bodies that are members of the Asia Pacific Laboratory Accreditation Cooperation (APLAC). In addition, the laboratories accredited by member bodies of the European Co-operation for Accreditation (EA), the Inter American Accreditation Cooperation (IAAC) and other unaffiliated accreditation bodies also participated in this program. The program was coordinated by International Accreditation Japan (IAJapan) with the technical support from National Meteorology Institute of Japan (NMIJ) and Mitutoyo Corporation as collaborators.

This program was the eighteenth APLAC calibration interlaboratory comparison. Circulation of the artefact commenced in July 2005 and finished in June 2006.

2. AIM OF THE PROGRAM

One of APLAC's main aims is to build up and maintain mutual confidence in the technical competence of APLAC members. Interlaboratory comparisons provide objective evidence that laboratories are competent and that they can achieve the level of accuracy for which they are accredited. They also provide a means for improving the quality and performance of laboratories throughout the region.

3. DESIGN OF THE PROGRAM

To enable as many calibration laboratories as possible who calibrate gauge blocks to participate in and to cover both methods for interferometry measurement and comparison measurement, multiple-loop type circulation was adopted.

For this interlaboratory comparison program, six sets of artefacts were prepared. A set of artefacts was prepared for a group for participating laboratories that perform interferometry measurements. The set of artefacts consists of three gauge blocks of which nominal length are 1 mm, 8 mm and 75 mm. The other five sets were prepared for groups for laboratories that perform comparison measurements and consist of three gauge blocks of which nominal length are 1 mm, 10 mm and 100 mm.

Participating laboratories were required to measure the central length of all gauge blocks under their normal conditions and calculate the deviations from assigned nominal length and report them to IAJapan.

The reference values of artefacts for interferometry measurement were assigned by NMIJ and those for comparison measurement by Mitutoyo's Miyazaki manufacturing department

which is accredited by IAJapan and is able to provide sufficiently small uncertainty (see Table 3 through Table 7) for comparison measurement.

Detailed procedures for measurements were instructed to participating laboratories as well as procedures for reporting surface conditions of artefacts as a monitoring means for checking validity of artefacts. A copy of the *Instructions to Laboratories* appears in Appendix B.

4. PARTICIPANTS

Eighty six laboratories from thirty one accreditation bodies in total participated in the program. A *Circulation Time Schedule* in Appendix C shows the name and economy of participating accreditation bodies. To maintain confidentiality, participating laboratories were assigned as random code and these numbers are used in the report. Table 1 shows the number of participating laboratories and their accreditation bodies for interferometry measurement group and comparison measurement groups.

Table 1 – Number of Participants

Calibration method	The number of Labs	The number of ABs
Interferometry	8(2)*	7
Comparison	78(4)*	30
Total	86(6)*	31

* The number inside of the parenthesis indicates the number of laboratories that had been registered but did not actually participate, and excluded from the number of participants.

5. REPORTING BY PARTICIPANTS

Laboratories were asked to report measurement results with associated measurement uncertainties at approximately 95 % level of confidence on a proforma *Result Sheet* and to submit the “*Surface Condition Report of Gauge Blocks*” (see Appendix B). They were also asked to provide *Calibration Certificates* for consideration of their accredited status.

6. ARTEFACTS

6.1 SPECIFICATION OF THE ARTEFACTS

The specifications of artefacts are shown in the Appendix B.

6.2 STABILITY OF THE ARTEFACTS

After initial calibration of the artefacts performed by NMIJ and Mitutoyo, they were sent

around all participating laboratories. After the circulation, the artefacts were recalibrated by NMIJ and Mitutoyo for checking validity and stability.

The results of the study for stability of the artefacts are as follows.

<Interferometry Measurement>

The difference of measured value of 75 mm gauge block by NMIJ before and after circulation was less than its expanded uncertainty, hence it was deemed to be sufficiently stable during circulation. On the other hand, the measured values of 1 mm and 8 mm gauge blocks in the measurement after circulation differed more than the expanded uncertainty from those before circulation. It was found in the investigation by NMIJ that there might be a problem in the Optical flats used for the measurement before circulation. It was also reported by NMIJ that no damage on the artefacts that might cause slippage of measurement data was observed. In addition to the above, the results of monitoring measured values by participants show that no systematic change was found during circulation. Therefore, the stability of overall artefacts is assumed to be sufficiently ensured whilst difference of the results of calibration by NMIJ between before and after circulation was observed.

<Comparison Measurement>

The differences of measured values of all gauge blocks before and after circulation were less than expanded uncertainty of reference laboratory (Mitutoyo), hence they were deemed to be sufficiently stable during circulation.

The results of stability study of the artefact appear in Appendix D.

7. REFERENCE VALUES

The reference values were determined as follows;

<Interferometry Measurement>

Since the problem was found in the measured values before circulation, the measurement results of after circulation with associated uncertainties of measurements were adopted as reference values for all artefacts for interferometry measurements. (see Section 6)

<Comparison Measurement>

The reference values for the artefacts for comparison measurement groups were assigned by Mitutoyo with interferometry measurement. Since the stability during circulation was confirmed to be adequate, the measurement results before circulation with associated uncertainties of measurements were adopted as reference values for all artefacts for comparison measurements.

The results of measurement for reference values are shown in Section 8.

8. SUMMARY OF RESULTS

The measurement results returned by the participating laboratories are summarised in the tables 2 to 7 below along with the results of performance analysis by the En number. The graphs in Figures 1 to 18 plot the difference between each laboratory's result and the reference value ($x_{lab}-X_{ref}$) and its associated uncertainty.

In accordance with international practice, performance of a participating laboratory has been assessed on the basis of the En number for each measurement. The En number is calculated using a standard statistical technique for comparing values and are derived from the equation (1).

$$En = \frac{x_{lab} - X_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}} \quad (1)$$

where

x_{lab} is the participating laboratory's result and X_{ref} is the reference laboratory's result derived from the equation (2) and (3) respectively:

$$x_{lab} = l_{cp} - l_n \quad \begin{array}{l} l_{cp}: \text{measured data of central length by the} \\ \text{participating laboratory} \end{array} \quad (2)$$

l_n : nominal central length

$$X_{ref} = l_{cr} - l_n \quad \begin{array}{l} l_{cr}: \text{measured data of central length by the} \\ \text{reference laboratory} \end{array} \quad (3)$$

l_n : nominal central length

U_{lab} is the laboratory's reported expanded uncertainty that provides an interval having a level of confidence of approximately 95 % (coverage factor $k=2$). U_{ref} is the expanded uncertainty of reference value (coverage factor $k=2$). For the results to be acceptable the En number should be between -1 and +1.

There are a number of cases that reported data in the results sheets are different from those in the calibration certificate. Details are described in Appendix E. For these cases, data in the calibration certificate were considered to be preceded and used in the statistical analysis.

While participating laboratories were asked to report the measurement uncertainties at the level of confidence approx. 95 %, i.e., $k = 2$, five laboratories reported their measurement uncertainties with the coverage factor k is not equal to 2. These coverage factors seem to be calculated with the degree of freedom at the level of confidence exactly 95 %.

To respect the reported value and to consider the pragmatic equivalence of the analysis, reported measurement uncertainties were used in the calculation of En numbers even if their coverage factors k are not equal to 2.

As the results of the analysis above, a laboratory had an outlier result while it will be within the range from -1 to 1 when En number is calculated for the modified measurement uncertainty with the coverage factor $k = 2$. For other results, the differences of the coverage factor do not affect on En numbers critically.

Table 2 - Results of Interferometry Measurement (Circulation roup:I-1)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	I1-1	I1-2	I1-3*	I1-4	I1-5	I1-6	I1-7	I1-8	I1-9	I1-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.014	0.039	0.016	0.0	0.03	0.07	0.005	0.015	0.024		
$x_{lab} - X_{ref}$	μm		0.025	0.002	-0.014	0.016	0.056	-0.009	0.001	0.010		
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		
Expanded Uncertainty: U	μm	0.017	0.040	0.030	0.62	0.04	0.03	0.025	0.040	0.020		
En numbers	-		0.58	0.06	-0.02	0.37	1.62	-0.30	0.02	0.38		

<Gauge Block: 8 mm>

Lab Code	Unit	Ref	I1-1	I1-2	I1-3*	I1-4	I1-5	I1-6	I1-7	I1-8	I1-9	I1-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.008	0.011	-0.007	0.0	-0.01	0.05	-0.018	-0.017	0.015		
$x_{lab} - X_{ref}$	μm		0.003	-0.015	-0.008	-0.018	0.042	-0.026	-0.025	0.007		
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		
Expanded Uncertainty: U	μm	0.017	0.040	0.030	0.62	0.04	0.03	0.030	0.040	0.020		
En numbers	-		0.07	-0.44	-0.01	-0.41	1.22	-0.75	-0.58	0.27		

<Gauge Block: 75 mm>

Lab Code	Unit	Ref	I1-1	I1-2	I1-3*	I1-4	I1-5	I1-6	I1-7	I1-8	I1-9	I1-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.049	-0.053	-0.071	-0.3	-0.08	-0.04	-0.068	-0.073	-0.058		
$x_{lab} - X_{ref}$	μm		-0.004	-0.022	-0.251	-0.031	0.009	-0.019	-0.024	-0.009		
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		
Expanded Uncertainty: U	μm	0.024	0.053	0.040	0.63	0.04	0.07	0.042	0.040	0.040		
En numbers	-		-0.07	-0.47	-0.40	-0.66	0.12	-0.39	-0.51	-0.19		

<Other Reported Information>

Lab Code	Unit	Ref	I1-1	I1-2	I1-3*	I1-4	I1-5	I1-6	I1-7	I1-8	I1-9	I1-10
Reference Standard	-	#1	#1	#2	#3	#1	#4	#2	#1	#1	-	-
Temperature	°C	19.99-20.04	20 ± 0.1	19.72-20.21	20.2 ± 0.5	20 ± 0.2	19.965	20 ± 0.2	20 ± 0.5	20 ± 0.1	-	-
Humidity	%	-	34 ± 2	49-51	-	55 ± 5	10.1 mbar	13.4-14.9 mbar	58 ± 15	less than 54	-	-

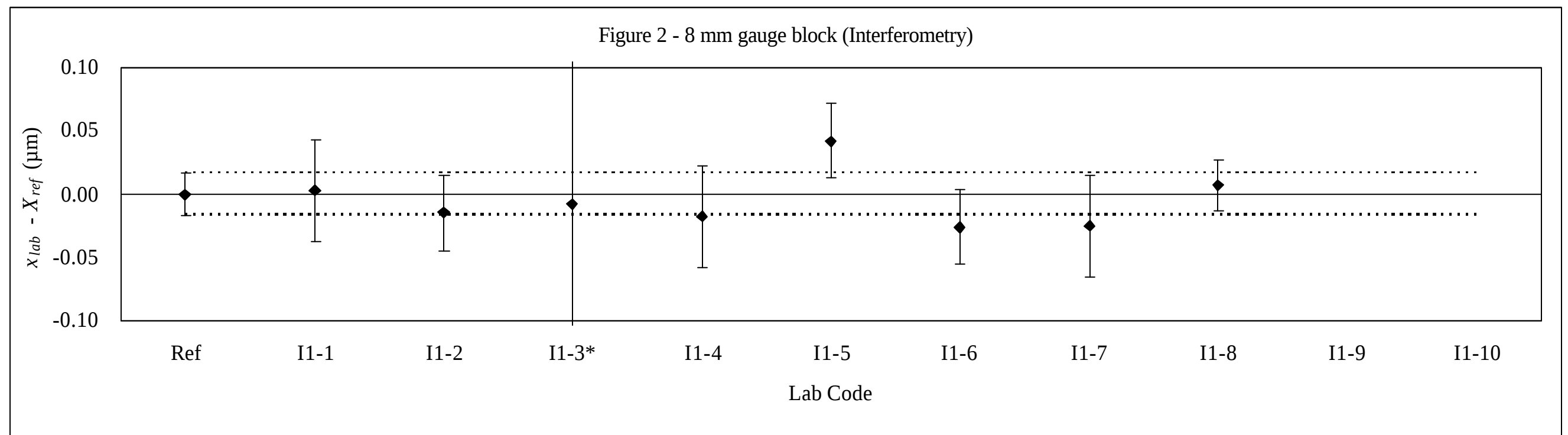
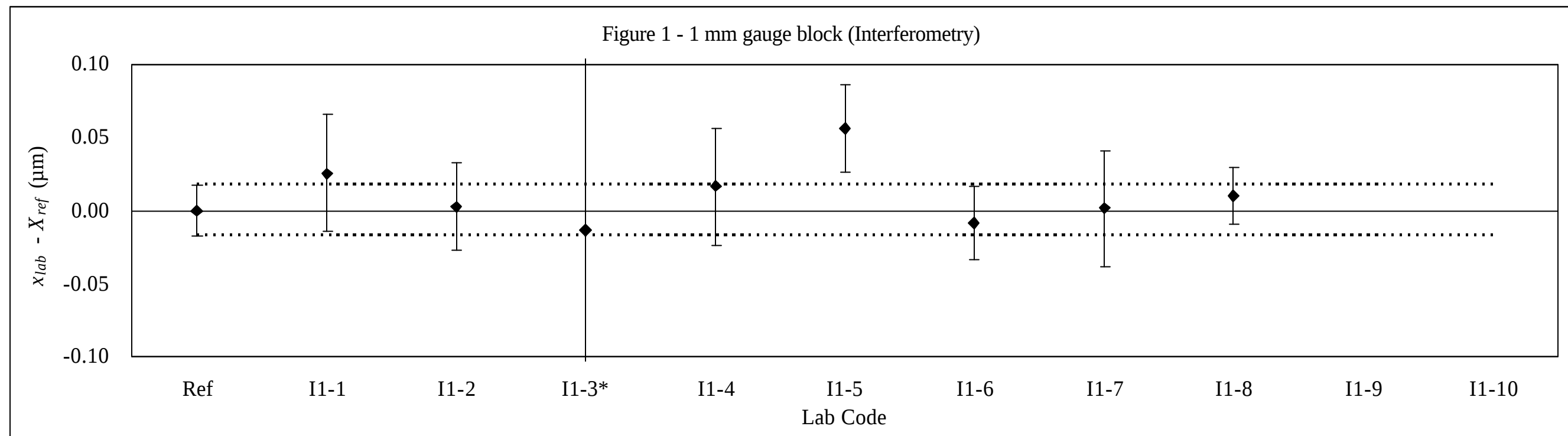
*: reported results are obtained by comparison measurement.

#1: 633 nm laser

#2: 633 nm laser and 543 nm laser

#3: Steel gauge blocks (no statement for grade)

#4: Spectral lamps Cadmium - 144 (1 mm & 8 mm) and Mercury - 198 (75 mm)



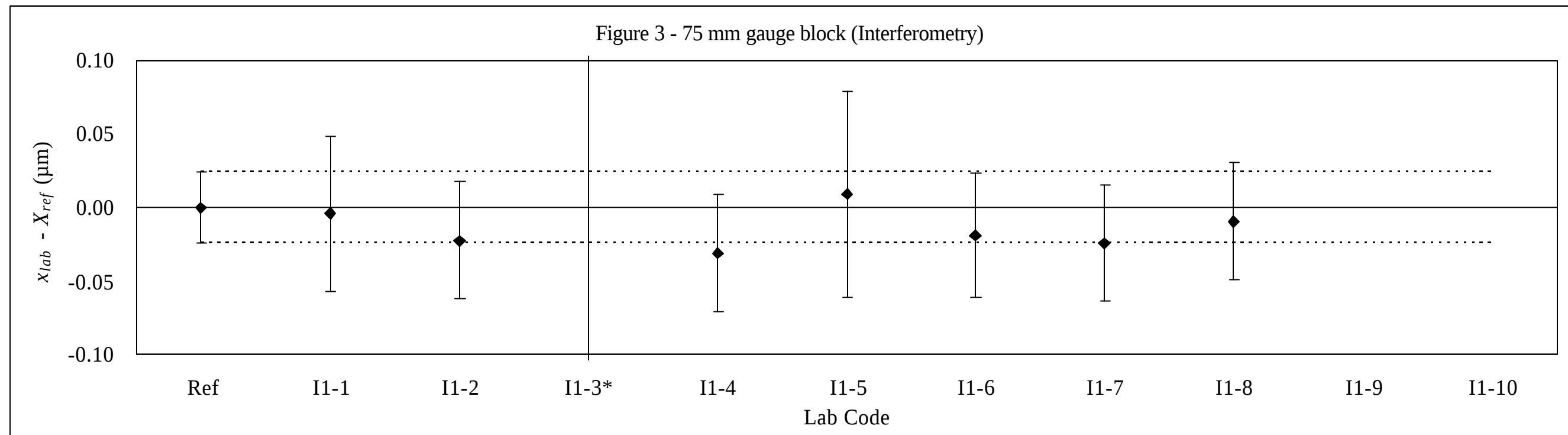


Table 3 - Results of Comparison Measurement (Circulation Group: C-1)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C1-1	C1-2	C1-3	C1-4	C1-5	C1-6	C1-7	C1-8	C1-9	C1-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.051	0.05	0.06	0.04	0.05	0.06	0.05	0.08	0.07	0.03	0.01
$x_{lab} - X_{ref}$	μm		-0.001	0.009	-0.011	-0.001	0.009	-0.001	0.029	0.019	-0.021	-0.041
Coverage Factor: k	-	2	2	2	2	2	2	2	1.96	2	1.96	2
Expanded Uncertainty: U	μm	0.030	0.08	0.07	0.07	0.051	0.06	0.16	0.06	0.08	0.07	0.033
En numbers	-		-0.01	0.12	-0.14	-0.02	0.13	-0.01	0.43	0.22	-0.28	-0.92

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C1-1	C1-2	C1-3	C1-4	C1-5	C1-6	C1-7	C1-8	C1-9	C1-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.034	-0.04	-0.01	-0.02	-0.04	-0.01	-0.04	0.00	0.01	-0.04	-0.04
$x_{lab} - X_{ref}$	μm		-0.006	0.024	0.014	-0.006	0.024	-0.006	0.034	0.044	-0.006	-0.006
Coverage Factor: k	-	2	2	2	2	2	2	2	1.96	2	1.96	2
Expanded Uncertainty: U	μm	0.030	0.08	0.07	0.07	0.062	0.06	0.16	0.06	0.08	0.08	0.036
En numbers	-		-0.07	0.32	0.18	-0.09	0.36	-0.04	0.51	0.51	-0.07	-0.13

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C1-1	C1-2	C1-3	C1-4	C1-5	C1-6	C1-7	C1-8	C1-9	C1-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.066	0.03	0.14	0.08	0.05	0.06	0.00	0.22	0.07	0.05	-0.07
$x_{lab} - X_{ref}$	μm		-0.036	0.074	0.014	-0.016	-0.006	-0.066	0.154	0.004	-0.016	-0.136
Coverage Factor: k	-	2	2	2	2	2	2	2	1.97	2	1.96	2
Expanded Uncertainty: U	μm	0.030	0.08	0.12	0.14	0.170	0.06	0.16	0.15	0.08	0.18	0.11
En numbers	-		-0.42	0.60	0.10	-0.09	-0.09	-0.41	1.01	0.05	-0.09	-1.19

<Other Reported Information>

Lab Code	Unit	Ref	C1-1	C1-2	C1-3	C1-4	C1-5	C1-6	C1-7	C1-8	C1-9	C1-10
Reference Standard	-	#1	#2	#2	#3	#3	#2	#4	#5	#3	#3	#6
Temperature	°C	-	20 ± 0.5	20 ± 0.3	19.8 ± 0.5	20 ± 1	20 ± 1	20.0	20 ± 1	20 ± 1	20 ± 1	20.3
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	11.0 ± 1.0	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 1.0	10.8 ± 0.5	10.8 ± 0.5

- #1: 633 nm laser
#2: Steel gauge blocks (no statement for grade)
#3: Steel gauge block (Grade 00 or K)
#4: Steel gauge block (Grade 2)
#5: Gauge blocks (no statement for grade and material)
#6: Gauge block (Grade K, no statement for material)
#7: Gauge block (Grade 0, no statement for material)
#8: Ceramic gauge block (Grade 00)

Table 3 - Results of Comparison Measurement (Circulation Group: C-1)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C1-11	C1-12	C1-13	C1-14	C1-15
Deviation of Central Length from nominal: l_c-l_n	μm	0.051	0.07	0.01	0.06		0.09
$x_{lab} - X_{ref}$	μm		0.019	-0.041	0.009		0.039
Coverage Factor: k	-	2	2	2	2		2.20
Expanded Uncertainty: U	μm	0.030	0.20	0.08	0.07		0.041
En numbers	-		0.09	-0.48	0.12		0.77

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C1-11	C1-12	C1-13	C1-14	C1-15
Deviation of Central Length from nominal: l_c-l_n	μm	-0.034	0.08	0.01	-0.03		0.05
$x_{lab} - X_{ref}$	μm		0.114	0.044	0.004		0.084
Coverage Factor: k	-	2	2	2	2		2.11
Expanded Uncertainty: U	μm	0.030	0.23	0.08	0.07		0.049
En numbers	-		0.49	0.51	0.05		1.46

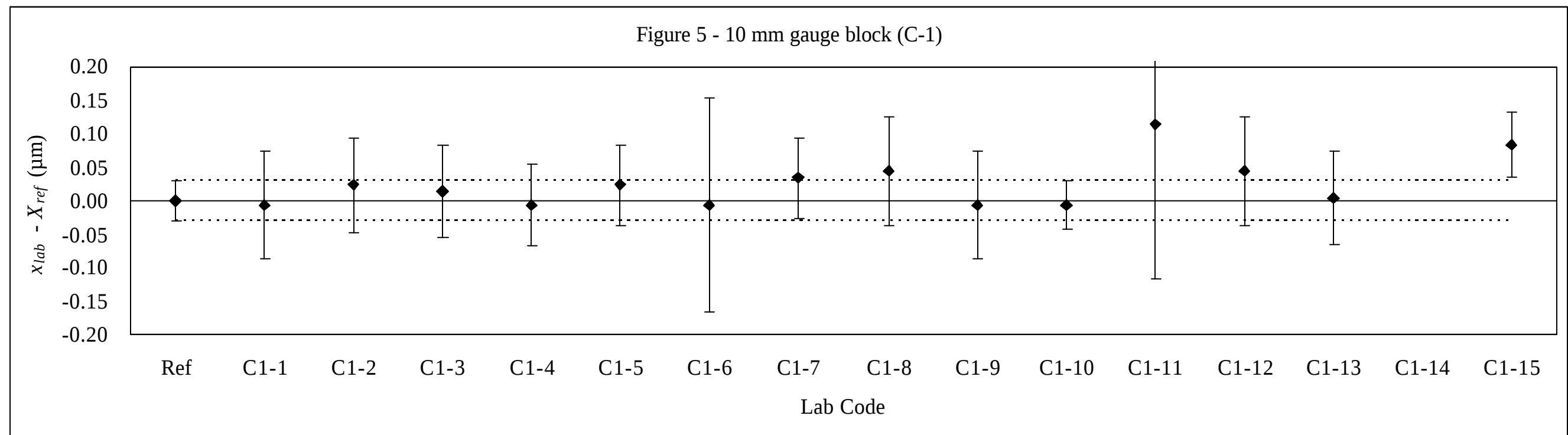
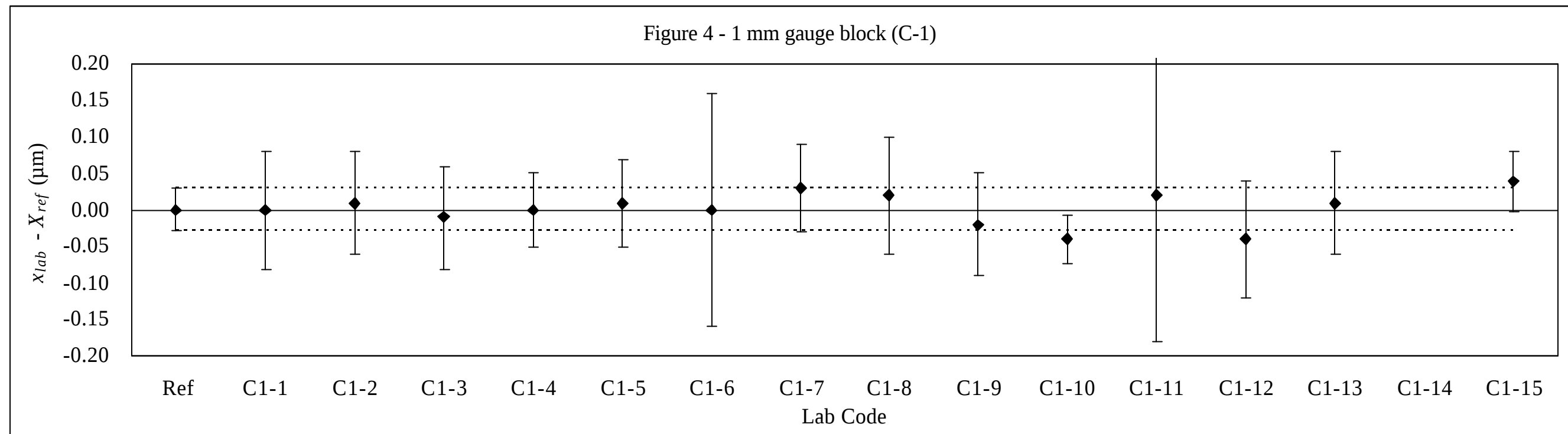
<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C1-11	C1-12	C1-13	C1-14	C1-15
Deviation of Central Length from nominal: l_c-l_n	μm	0.066	-0.15	0.08	0.07		0.11
$x_{lab} - X_{ref}$	μm		-0.216	0.014	0.004		0.044
Coverage Factor: k	-	2	2	2	2		1.98
Expanded Uncertainty: U	μm	0.030	0.5	0.15	0.07		0.160
En numbers	-		-0.43	0.09	0.05		0.27

<Other Reported Information>

Lab Code	Unit	Ref	C1-11	C1-12	C1-13	C1-14	C1-15
Reference Standard	-	#1	#7	#2	#2	-	#8
Temperature	$^{\circ}\text{C}$	-	21 ± 2	20.1 ± 0.1	20 ± 0.5	-	19.8
Thermal expansion coefficient	10^{-6} K^{-1}	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 1.0	-	11.5

- #1: 633 nm laser
- #2: Steel gauge blocks (no statement for grade)
- #3: Steel gauge block (Grade 00 or K)
- #4: Steel gauge block (Grade 2)
- #5: Gauge blocks (no statement for grade and material)
- #6: Gauge block (Grade K, no statement for material)
- #7: Gauge block (Grade 0, no statement for material)
- #8: Ceramic gauge block (Grade 00)



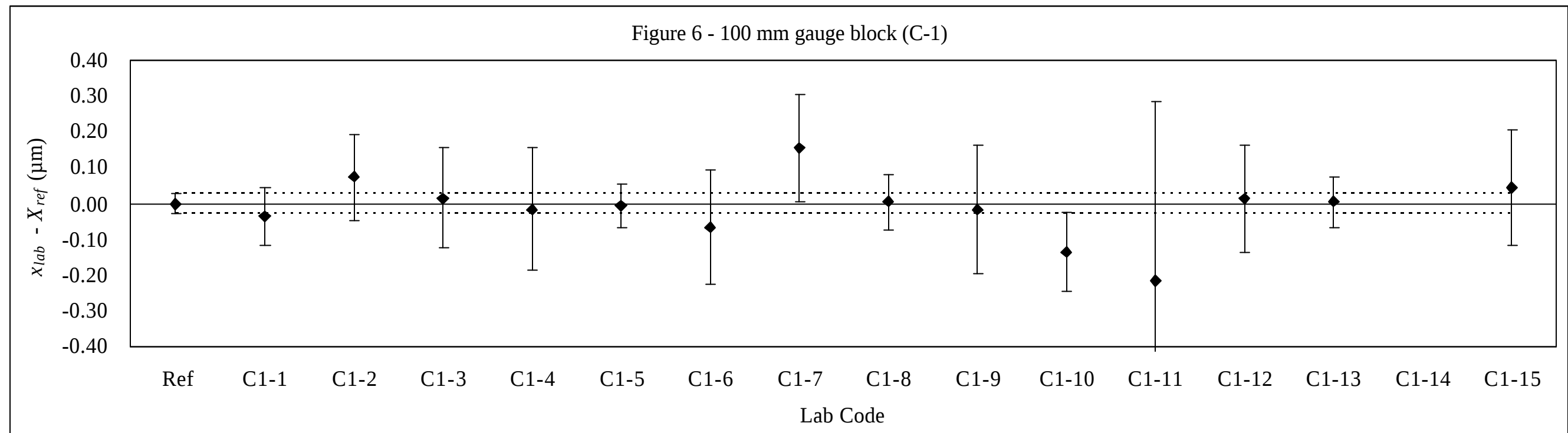


Table 4 - Results of Comparison Measurement (Circulation Group: C-2)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C2-1	C2-2	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.019	0.04	-0.01	0.01	0.01	0.11	0.02	0.019	-0.09	0.06	0.08
$x_{lab} - X_{ref}$	μm		0.021	-0.029	-0.009	-0.009	0.091	0.001	0.000	-0.109	0.041	0.061
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2.01	2
Expanded Uncertainty: U	μm	0.030	0.040	0.08	0.05	0.067	0.08	0.75	0.06	0.31	0.09	0.09
En numbers	-		0.42	-0.34	-0.15	-0.12	1.07	0.00	0.00	-0.35	0.43	0.64

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C2-1	C2-2	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.008	-0.03	0.01	-0.01	0.01	0.03	0.01	-0.061	-0.10	0.01	0.10
$x_{lab} - X_{ref}$	μm		-0.038	0.002	-0.018	0.002	0.022	0.002	-0.069	-0.108	0.002	0.092
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2.01	2
Expanded Uncertainty: U	μm	0.030	0.040	0.08	0.05	0.075	0.08	0.75	0.07	0.31	0.09	0.09
En numbers	-		-0.76	0.02	-0.31	0.02	0.26	0.00	-0.91	-0.35	0.02	0.97

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C2-1	C2-2	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.082	-0.04	-0.16	0.02	0.02	0.16	0.03	-0.189	0.01	-0.05	0.10
$x_{lab} - X_{ref}$	μm		0.042	-0.078	0.102	0.102	0.242	0.112	-0.107	0.092	0.032	0.182
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2.01	2
Expanded Uncertainty: U	μm	0.030	0.19	0.18	0.14	0.277	0.18	0.75	0.11	0.34	0.20	0.18
En numbers	-		0.22	-0.43	0.71	0.37	1.33	0.15	-0.94	0.27	0.16	1.00

<Other Reported Information>

Lab Code	Unit	Ref	C2-1	C2-2	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
Reference Standard	-	#1	#2	#3	#4	#5	#4	#4	#5	#6	#4	#7
Temperature	°C	-	20 ± 2	20 ± 0.1	20.0 ± 0.3	20.5	20 ± 0.5	20 ± 1	20 ± 0.5	20 ± 1	19.7	20 ± 0.5
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	11.7 ± 0.3	10.8 ± 0.5	10.6 ± 0.1	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5

#1: 633 nm laser

#2: Ceramic gauge block (Grade K)

#3: Tungsten carbide gauge blocks (Grade 00 or K)

#4: Steel gauge block (Grade 00 or K)

#5: Steel gauge blocks (no statement for grade)

#6: Gauge blocks (no statement for grade and material)

#7: Tungsten carbide gauge blocks (no statement for grade)

#8: Steel Gauge block (Grade 0)

Table 4 - Results of Comparison Measurement (Circulation Group: C-2)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C2-11	C2-12	C2-13	C2-14	C2-15	C2-16	C2-17	C2-18	C2-19
Deviation of Central Length from nominal: l_c-l_n	μm	0.019	0.01	0.01	-0.04	-0.064	0.04	0.00	0.01	0.01	0.09
$x_{lab} - X_{ref}$	μm		-0.009	-0.009	-0.059	-0.083	0.021	-0.019	-0.009	-0.009	0.071
Coverage Factor: k	-	2	2	2	2	not reported	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.06	0.07	0.054	0.379	0.3	0.053	0.11	0.05	0.13
En numbers	-		-0.13	-0.12	-0.96	-0.22	0.07	-0.31	-0.08	-0.15	0.53

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C2-11	C2-12	C2-13	C2-14	C2-15	C2-16	C2-17	C2-18	C2-19
Deviation of Central Length from nominal: l_c-l_n	μm	0.008	0.00	-0.02	-0.07	-0.076	-0.05	0.00	0.03	0.01	-0.06
$x_{lab} - X_{ref}$	μm		-0.008	-0.028	-0.078	-0.084	-0.058	-0.008	0.022	0.002	-0.068
Coverage Factor: k	-	2	2	2	2	not reported	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.07	0.08	0.054	0.379	0.3	0.053	0.21	0.05	0.13
En numbers	-		-0.11	-0.33	-1.26	-0.22	-0.19	-0.13	0.10	0.03	-0.51

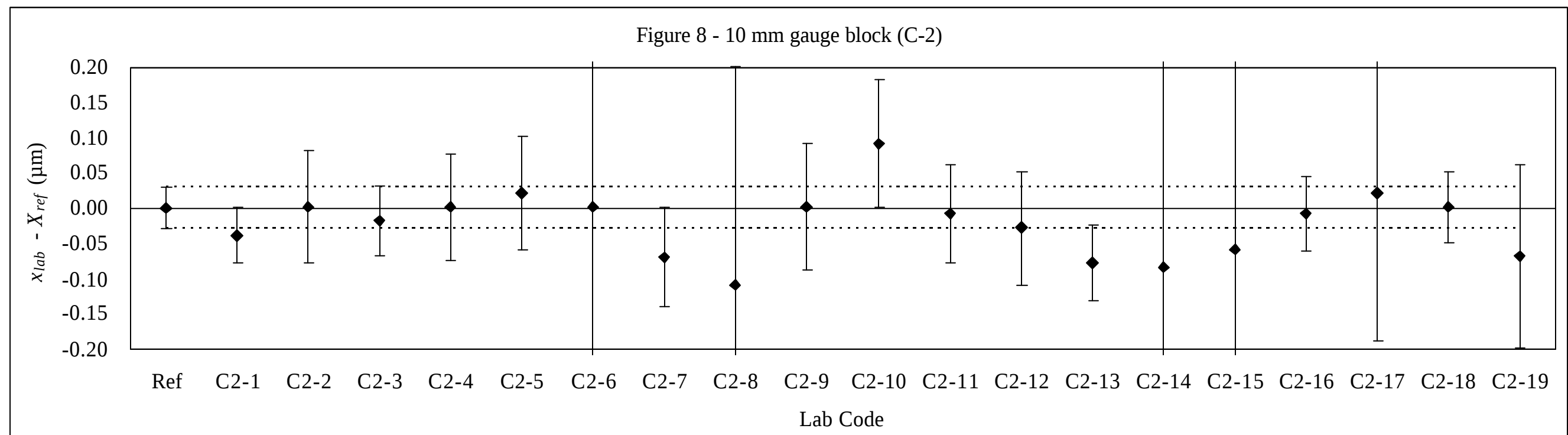
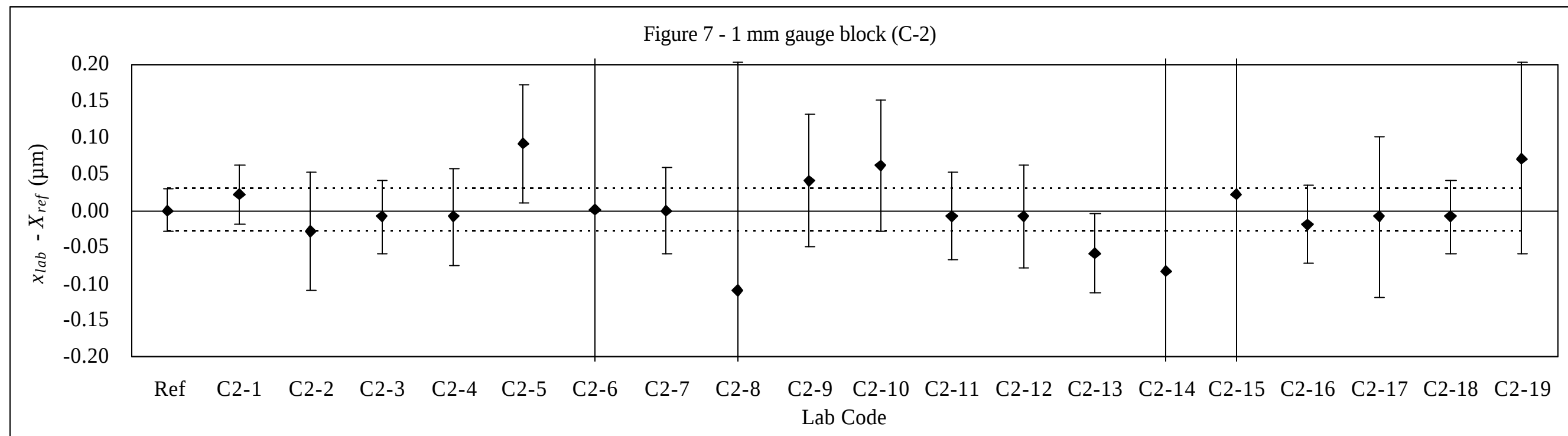
<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C2-11	C2-12	C2-13	C2-14	C2-15	C2-16	C2-17	C2-18	C2-19
Deviation of Central Length from nominal: l_c-l_n	μm	-0.082	0.02	0.00	0.04	-0.130	-0.30	-0.03	-0.07	-0.19	-0.48
$x_{lab} - X_{ref}$	μm		0.102	0.082	0.122	-0.048	-0.218	0.052	0.012	-0.108	-0.398
Coverage Factor: k	-	2	2	2	2	not reported	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.18	0.10	0.15	0.378	0.5	0.15	0.26	0.05	0.14
En numbers	-		0.56	0.79	0.80	-0.13	-0.44	0.34	0.05	-1.85	-2.78

<Other Reported Information>

Lab Code	Unit	Ref	C2-11	C2-12	C2-13	C2-14	C2-15	C2-16	C2-17	C2-18	C2-19
Reference Standard	-	#1	#4	#6	#3	not reported	#2	#4	#3	#4	#8
Temperature	°C	-	20 ± 0.2	20 ± 1	20 ± 1	20	20 ± 2	20 ± 1	20 ± 1	20 ± 0.2	20 ± 0.2
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 1.0	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5

- #1: 633 nm laser
#2: Ceramic gauge block (Grade K)
#3: Tungsten carbide gauge blocks (Grade 00 or K)
#4: Steel gauge block (Grade 00 or K)
#5: Steel gauge blocks (no statement for grade)
#6: Gauge blocks (no statement for grade and material)
#7: Tungsten carbide gauge blocks (no statement for grade)
#8: Steel Gauge block (Grade 0)



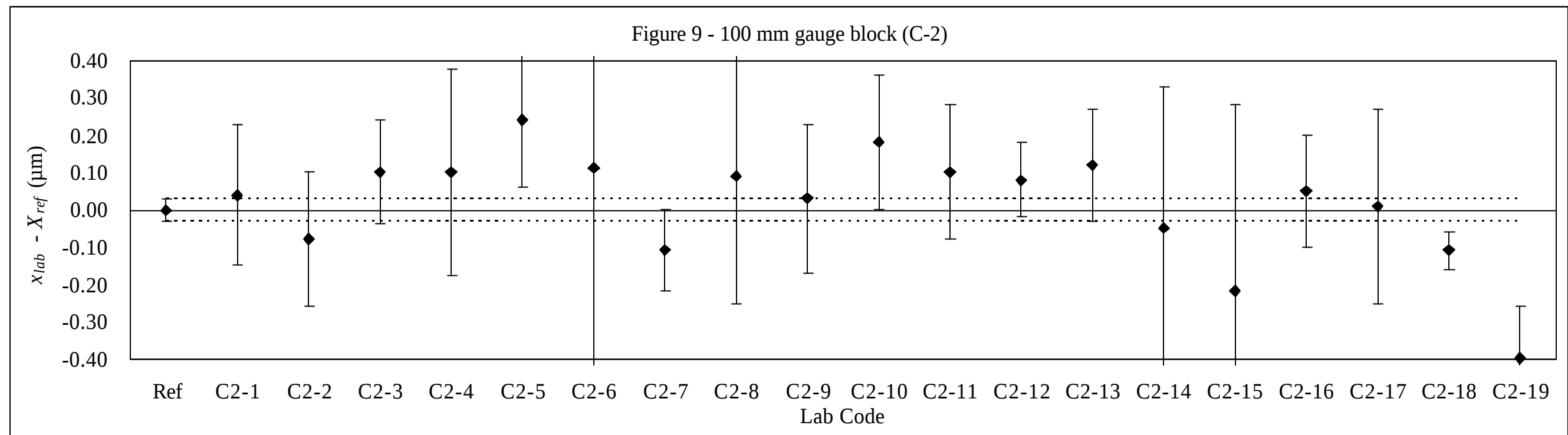


Table 5 - Results of Comparison Measurement (Circulation Group: C-3)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C3-1	C3-2	C3-3	C3-4	C3-5	C3-6	C3-7	C3-8	C3-9	C3-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.022	0.036	0.073	0.03	0.02	0.01	0.03	0.12	0.08		0.01
$x_{lab} - X_{ref}$	μm		0.014	0.051	0.008	-0.002	-0.012	0.008	0.098	0.058		-0.012
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		2
Expanded Uncertainty: U	μm	0.030	0.079	0.07	0.14	0.064	0.00093	0.12	0.05	0.08		0.10
En numbers	-		0.17	0.67	0.06	-0.03	-0.40	0.06	1.68	0.68		-0.11

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C3-1	C3-2	C3-3	C3-4	C3-5	C3-6	C3-7	C3-8	C3-9	C3-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.030	0.034	0.001	0.02	-0.03	0.02	0.00	0.06	0.09		-0.04
$x_{lab} - X_{ref}$	μm		0.064	0.031	0.050	0.000	0.050	0.030	0.090	0.120		-0.010
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		2
Expanded Uncertainty: U	μm	0.030	0.079	0.10	0.14	0.064	0.00093	0.12	0.05	0.08		0.11
En numbers	-		0.76	0.30	0.35	0.00	1.67	0.24	1.54	1.40		-0.09

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C3-1	C3-2	C3-3	C3-4	C3-5	C3-6	C3-7	C3-8	C3-9	C3-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.093	0.028	0.205	0.15	0.13	0.14	0.26	0.20	0.19		0.19
$x_{lab} - X_{ref}$	μm		-0.065	0.112	0.057	0.037	0.047	0.167	0.107	0.097		0.097
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2		2
Expanded Uncertainty: U	μm	0.030	0.087	0.37	0.22	0.213	0.1052	0.20	0.09	0.18		0.13
En numbers	-		-0.71	0.30	0.26	0.17	0.43	0.83	1.13	0.53		0.73

<Other Reported Information>

Lab Code	Unit	Ref	C3-1	C3-2	C3-3	C3-4	C3-5	C3-6	C3-7	C3-8	C3-9	C3-10
Reference Standard	-	#1	#2	#2	#2	#2	#2	not reported	#2	#3		#2
Temperature	°C	-	20 ± 0.25	20.6	20.0	20.08	20.3	20 ± 0.5	20 ± 0.1	19.9		20 ± 1
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	11.7	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5		10.8 ± 0.5

- #1: 633 nm laser
#2: Steel gauge blocks (no garade reported)
#3: Steel gauge blocks (Grade 00 or K)
#4: Tungsten carbide gauge blocks (Grade K)
#5: Steel gauge block (Grade 0)
#6: Gauge blocks (no statement for garade and material)

Table 5 - Results of Comparison Measurement (Circulation Group: C-3)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C3-11	C3-12	C3-13	C3-14	C3-15
Deviation of Central Length from nominal: l_c-l_n	μm	0.022	0.07	-0.01	0.02	0.07	0.02
$x_{lab} - X_{ref}$	μm		0.048	-0.032	-0.002	0.048	-0.002
Coverage Factor: k	-	2	1.96	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.060	0.12	0.05	0.13	0.074
En numbers	-		0.72	-0.26	-0.03	0.36	-0.03

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C3-11	C3-12	C3-13	C3-14	C3-15
Deviation of Central Length from nominal: l_c-l_n	μm	-0.030	0.02	-0.02	-0.01	0.02	-0.02
$x_{lab} - X_{ref}$	μm		0.050	0.010	0.020	0.050	0.010
Coverage Factor: k	-	2	1.96	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.063	0.12	0.07	0.13	0.082
En numbers	-		0.72	0.08	0.26	0.37	0.11

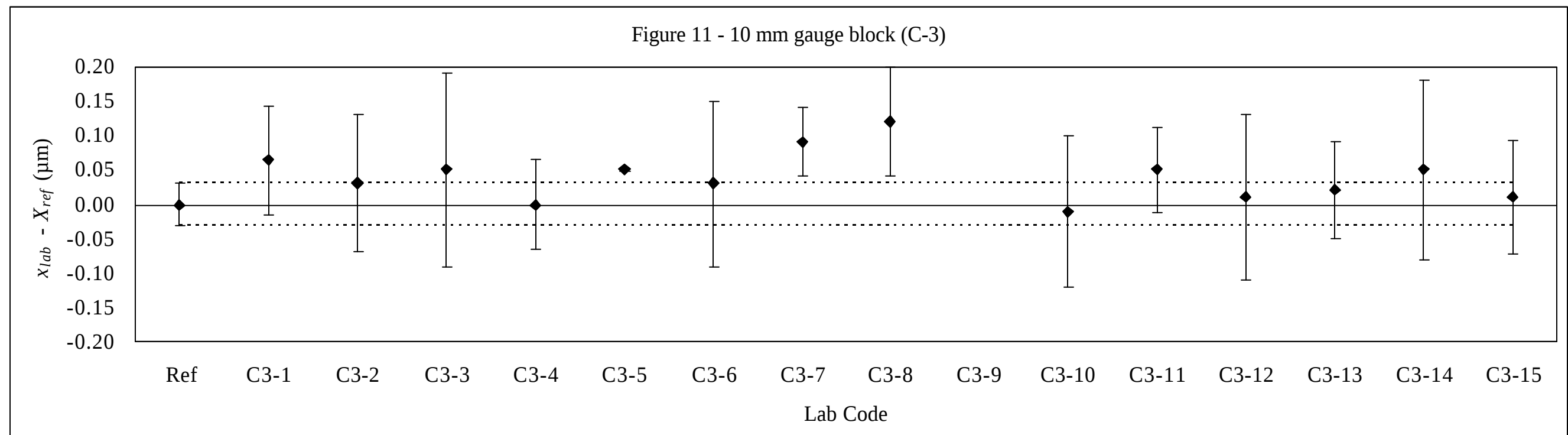
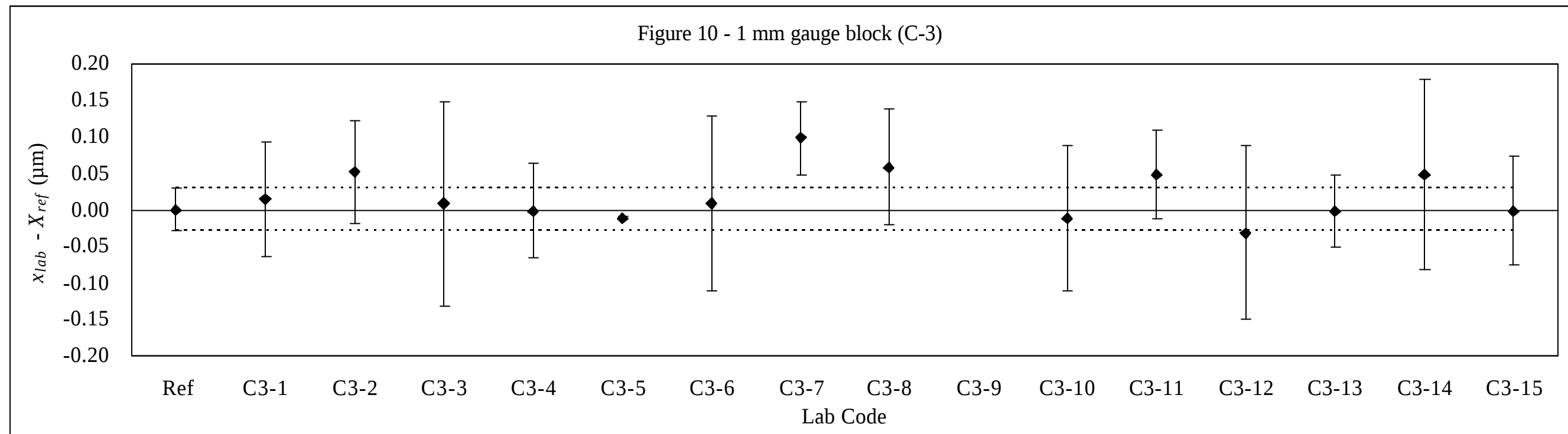
<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C3-11	C3-12	C3-13	C3-14	C3-15
Deviation of Central Length from nominal: l_c-l_n	μm	0.093	-0.16	0.28	0.17	0.41	0.12
$x_{lab} - X_{ref}$	μm		-0.253	0.187	0.077	0.317	0.027
Coverage Factor: k	-	2	2.01	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.142	0.2	0.35	0.30	0.161
En numbers	-		-1.74	0.92	0.22	1.05	0.16

<Other Reported Information>

Lab Code	Unit	Ref	C3-11	C3-12	C3-13	C3-14	C3-15
Reference Standard	-	#1	#4	#3	#2	#5	#6
Temperature	°C	-	20	20	20	20.6	20
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	11.5 ± 1.0	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5

- #1: 633 nm laser
#2: Steel gauge blocks (no garade reported)
#3: Steel gauge blocks (Grade 00 or K)
#4: Tungsten carbide gauge blocks (Grade K)
#5: Steel gauge block (Grade 0)
#6: Gauge blocks (no statement for garade and material)



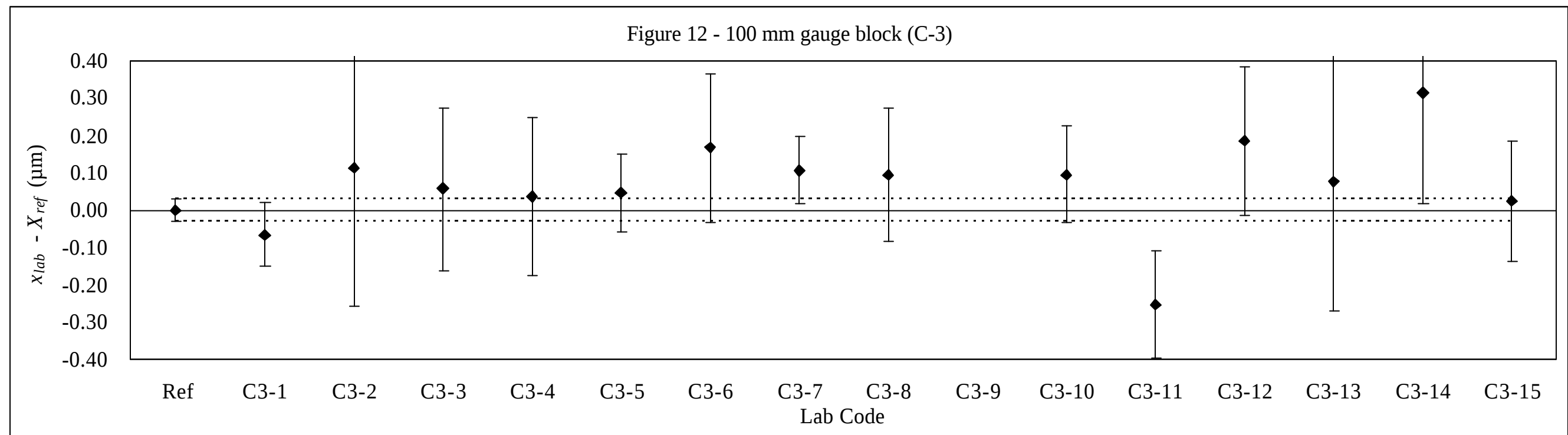


Table 6 - Results of Comparison Measurement (Circulation Group: C-4)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C4-1	C4-2	C4-3	C4-4	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.014	0.00	0.05	0.00	0.01	0.02	0.02	0.03	-0.330	0.05	0.065
$x_{lab} - X_{ref}$	μm		-0.014	0.036	-0.014	-0.004	0.006	0.006	0.016	-0.344	0.036	0.051
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.05	0.06	0.08	0.08	0.09	0.064	0.20	0.19	0.03	0.07
En numbers	-		-0.24	0.54	-0.16	-0.05	0.06	0.08	0.08	-1.79	0.85	0.67

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C4-1	C4-2	C4-3	C4-4	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.025	-0.03	0.01	-0.03	-0.02	-0.02	-0.06	-0.01	0.030	-0.08	-0.013
$x_{lab} - X_{ref}$	μm		-0.005	0.035	-0.005	0.005	0.005	-0.035	0.015	0.055	-0.055	0.012
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.06	0.06	0.09	0.08	0.09	0.064	0.17	0.22	0.03	0.08
En numbers	-		-0.07	0.52	-0.05	0.06	0.05	-0.50	0.09	0.25	-1.30	0.14

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C4-1	C4-2	C4-3	C4-4	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.012	-0.02	0.04	-0.07	-0.03	0.02	-0.02	0.25	0.020	0.37	-0.046
$x_{lab} - X_{ref}$	μm		-0.008	0.052	-0.058	-0.018	0.032	-0.008	0.262	0.032	0.382	-0.034
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.11	0.13	0.13	0.14	0.15	0.130	0.38	0.56	0.11	0.19
En numbers	-		-0.07	0.39	-0.43	-0.13	0.21	-0.06	0.69	0.06	3.35	-0.18

<Other Reported Information>

Lab Code	Unit	Ref	C4-1	C4-2	C4-3	C4-4	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
Reference Standard	-	#1	#2	#3	#4	#5	#2	#5	#6	#3	#2	#7
Temperature	°C	-	20	19.98-20.04	20 ± 0.1	20.0 ± 0.3	20.0 ± 0.6	19.9 ± 0.2	20	20	20.0 ± 0.5	19.9 ± 0.4
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.9 ± 1	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	11.5 ± 1	10.8 ± 0.5

#1: 633 nm laser

#2: Steel gauge blocks (Grade 00 or K)

#3: Steel gauge blocks (no grade reported)

#4: Gauge blocks (no statement for grade and material)

#5: Gauge blocks (Grade 00 or K, no statement for material)

#6: Steel gauge blocks (Grade 0)

#7: Crome-carbide gauge blocks (Grade K)

#8: Micrometer

Table 6 - Results of Comparison Measurement (Circulation Group: C-4)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C4-11	C4-12	C4-13	C4-14	C4-15	C4-16
Deviation of Central Length from nominal: l_c-l_n	μm	0.014	0.04	0.04	0.00			1
$x_{lab} - X_{ref}$	μm		0.026	0.026	-0.014			0.986
Coverage Factor: k	-	2	2	2	2			2
Expanded Uncertainty: U	μm	0.030	0.05	0.09	0.09			4
En numbers	-		0.45	0.27	-0.15			0.25

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C4-11	C4-12	C4-13	C4-14	C4-15	C4-16
Deviation of Central Length from nominal: l_c-l_n	μm	-0.025	0.00	-0.11	-0.08			1
$x_{lab} - X_{ref}$	μm		0.025	-0.085	-0.055			1.025
Coverage Factor: k	-	2	2	2	2			2
Expanded Uncertainty: U	μm	0.030	0.05	0.09	0.10			4
En numbers	-		0.43	-0.90	-0.53			0.26

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C4-11	C4-12	C4-13	C4-14	C4-15	C4-16
Deviation of Central Length from nominal: l_c-l_n	μm	-0.012	0.04	-0.01	0.08			
$x_{lab} - X_{ref}$	μm		0.052	0.002	0.092			
Coverage Factor: k	-	2	2	2	2			
Expanded Uncertainty: U	μm	0.030	0.13	0.12	0.18			
En numbers	-		0.39	0.02	0.50			

<Other Reported Information>

Lab Code	Unit	Ref	C4-11	C4-12	C4-13	C4-14	C4-15	C4-16
Reference Standard	-	#1	#5	#3	#2			#8
Temperature	°C	-	20 ± 0.5	20 ± 2	20 ± 0.5			21.7
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5			10.8 ± 0.5

#1: 633 nm laser

#2: Steel gauge blocks (Grade 00 or K)

#3: Steel gauge blocks (no grade reported)

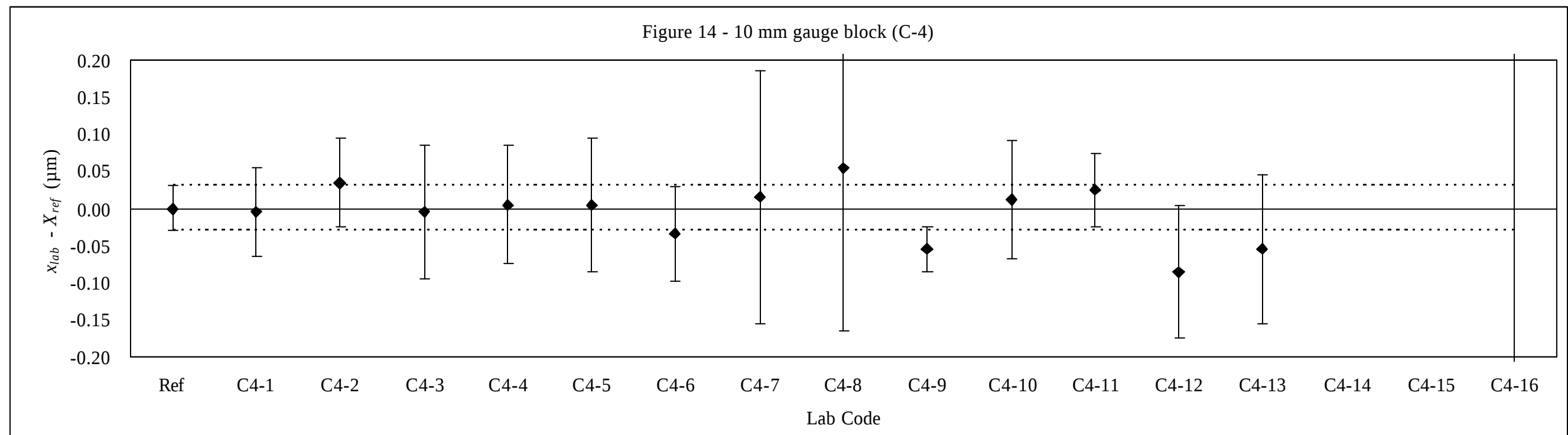
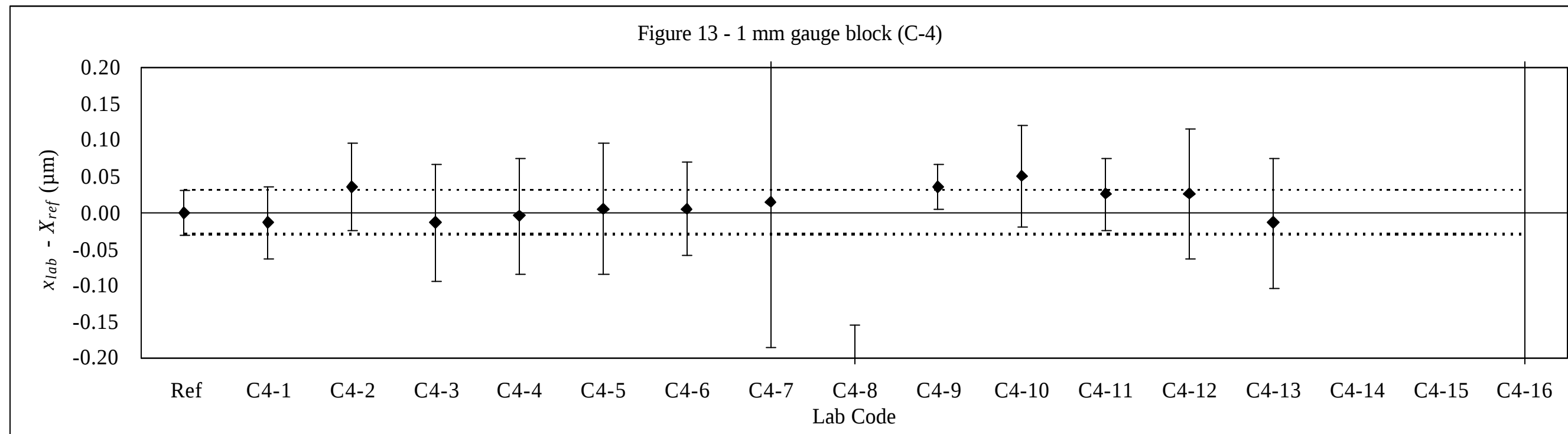
#4: Gauge blocks (no statement for grade and material)

#5: Gauge blocks (Grade 00 or K, no statement for material)

#6: Steel gauge blocks (Grade 0)

#7: Crome-carbide gauge blocks (Grade K)

#8: Micrometer



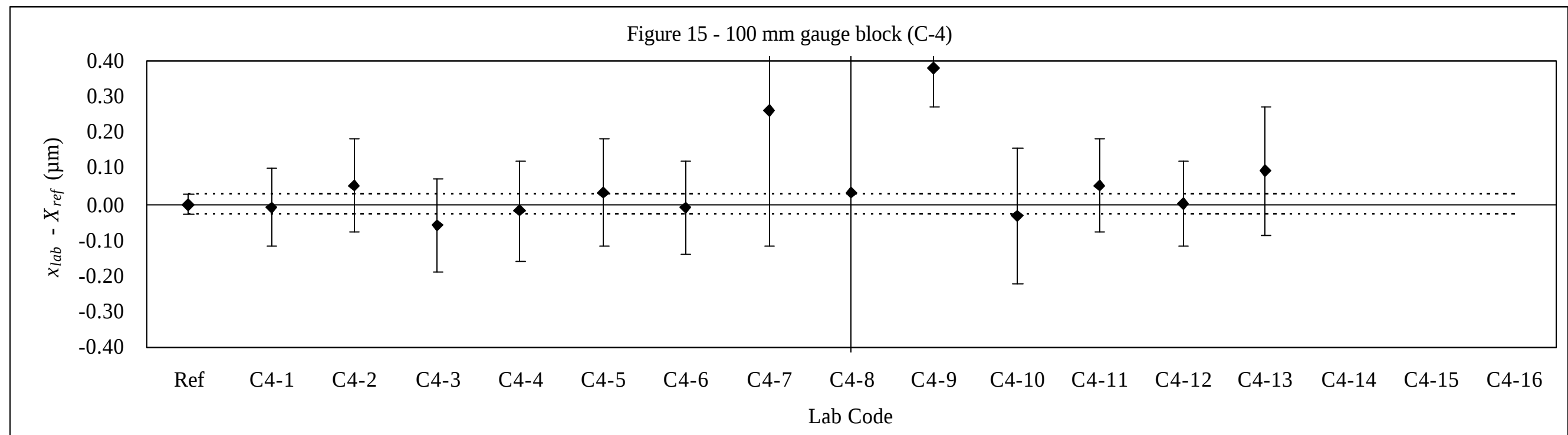


Table 7 - Results of Comparison Measurement (Circulation Group: C-5)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.009	-0.03	0.021	-0.04	-0.01	-0.01	0.02	0.02	-0.02	0.03	0.07
$x_{lab} - X_{ref}$	μm		-0.021	0.030	-0.031	-0.001	-0.001	0.029	0.029	-0.011	0.039	0.079
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.08	0.10	0.070	0.10	0.062	0.061	0.08	0.07	0.08	0.07
En numbers	-		-0.25	0.29	-0.41	-0.01	-0.01	0.43	0.34	-0.14	0.46	1.04

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
Deviation of Central Length from nominal: l_c-l_n	μm	-0.015	-0.03	0.038	0.01	-0.02	-0.05	0.03	0.02	-0.03	0.02	0.04
$x_{lab} - X_{ref}$	μm		-0.015	0.053	0.025	-0.005	-0.035	0.045	0.035	-0.015	0.035	0.055
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.08	0.11	0.074	0.11	0.074	0.066	0.08	0.07	0.08	0.07
En numbers	-		-0.18	0.46	0.31	-0.04	-0.44	0.62	0.41	-0.20	0.41	0.72

<Gauge Block: 100 mm>

Lab Code	Unit	Ref	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
Deviation of Central Length from nominal: l_c-l_n	μm	0.063	-0.07	0.178	0.05	-0.04	0.11	-0.02	0.12	0.01	0.19	0.20
$x_{lab} - X_{ref}$	μm		-0.133	0.115	-0.013	-0.103	0.047	-0.083	0.057	-0.053	0.127	0.137
Coverage Factor: k	-	2	2	2	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.18	0.20	0.11	0.20	0.20	0.12	0.18	0.12	0.18	0.13
En numbers	-		-0.73	0.57	-0.11	-0.51	0.23	-0.67	0.31	-0.43	0.70	1.03

<Other Reported Information>

Lab Code	Unit	Ref	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
Reference Standard	-	#1	#2	#3	#4	#2	#3	#5	#3	#2	#2	#6
Temperature	°C	-	20 ± 1	20 ± 1	20.0 ± 0.3	20 ± 0.3	20	20 ± 1	20 ± 0.5	20 ± 0.5	20 ± 1	20 ± 0.5
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	11.7	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	11.5 ± 1	11.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5

- #1: 633 nm laser
#2: Steel gauge blocks (no grade reported)
#3: Steel gauge blocks (Grade 00 or K)
#4: Gauge blocks (no statement for grade and material)
#5: Gauge blocks (Grade K, no statement for material)
#6: Steel gauge blocks (Grade 0)
#7: Ceramic gauge blocks (Grade K)

Table 7 - Results of Comparison Measurement (Circulation Group: C-5)

<Gauge Block: 1mm>

Lab Code	Unit	Ref	C5-11	C5-12	C5-13	C5-14	C5-15	C5-16	C5-17
Deviation of Central Length from nominal: l_c-l_n	μm	-0.009	-0.07	0.03	-0.02	0.02	-0.03	0.09	0.02
$x_{lab} - X_{ref}$	μm		-0.061	0.039	-0.011	0.029	-0.021	0.099	0.029
Coverage Factor: k	-	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.045	0.06	0.07	0.10	0.06	0.50	0.08
En numbers	-		-1.13	0.58	-0.14	0.28	-0.31	0.20	0.34

<Gauge Block: 10 mm>

Lab Code	Unit	Ref	C5-11	C5-12	C5-13	C5-14	C5-15	C5-16	C5-17
Deviation of Central Length from nominal: l_c-l_n	μm	-0.015	0.06	0.01	-0.03	-0.03	0.00	0.01	0.05
$x_{lab} - X_{ref}$	μm		0.075	0.025	-0.015	-0.015	0.015	0.025	0.065
Coverage Factor: k	-	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.052	0.08	0.07	0.11	0.07	0.50	0.12
En numbers	-		1.25	0.29	-0.20	-0.13	0.20	0.05	0.53

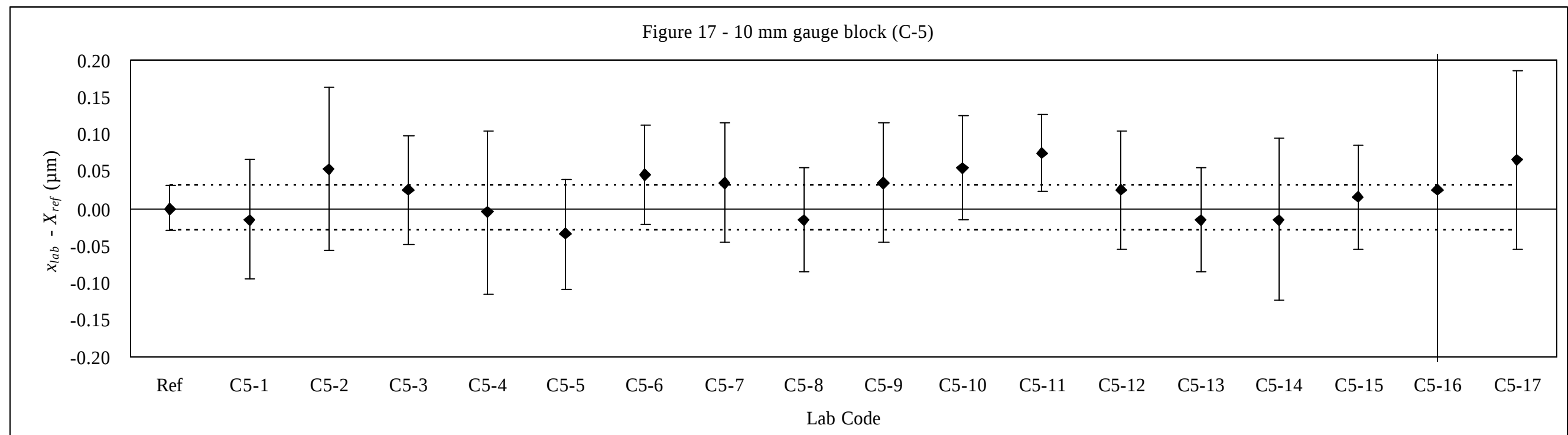
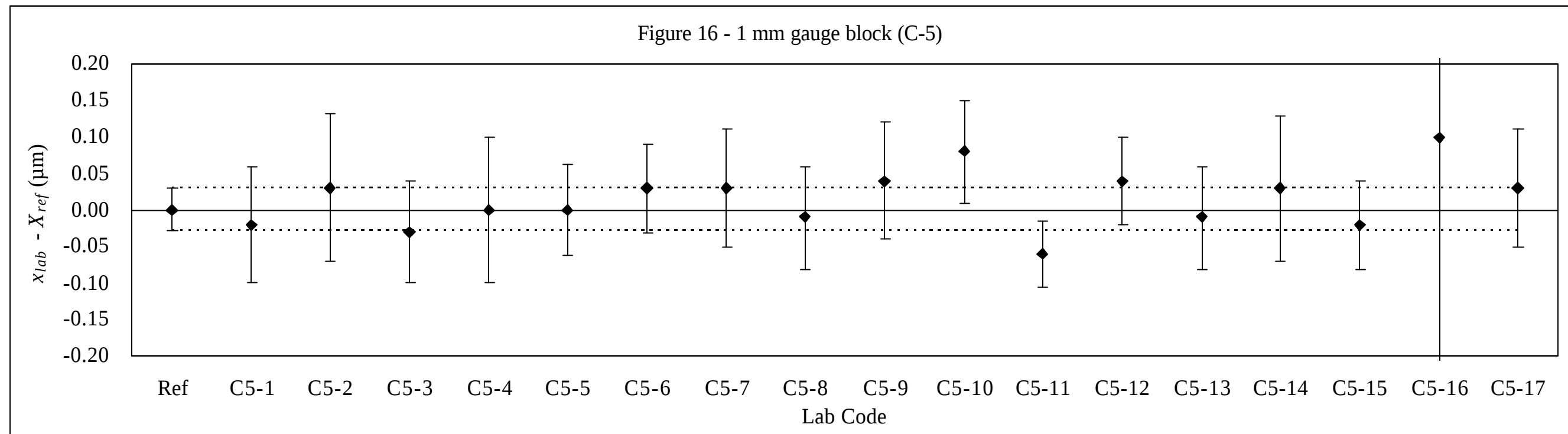
<Gauge Block: 100 mm>

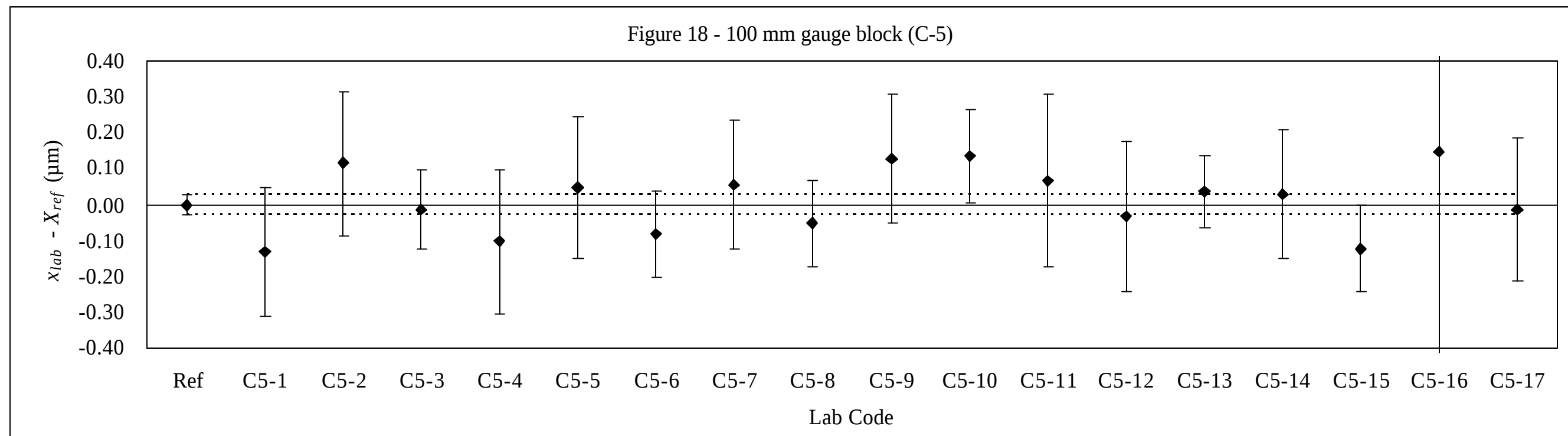
Lab Code	Unit	Ref	C5-11	C5-12	C5-13	C5-14	C5-15	C5-16	C5-17
Deviation of Central Length from nominal: l_c-l_n	μm	0.063	0.13	0.03	0.10	0.09	-0.06	0.21	0.05
$x_{lab} - X_{ref}$	μm		0.067	-0.033	0.037	0.027	-0.123	0.147	-0.013
Coverage Factor: k	-	2	2	2	2	2	2	2	2
Expanded Uncertainty: U	μm	0.030	0.241	0.21	0.10	0.18	0.12	0.70	0.20
En numbers	-		0.28	-0.16	0.35	0.15	-0.99	0.21	-0.06

<Other Reported Information>

Lab Code	Unit	Ref	C5-11	C5-12	C5-13	C5-14	C5-15	C5-16	C5-17
Reference Standard	-	#1	#3	#3	#2	#3	#2	#6	#7
Temperature	°C	-	19.00	19.7	20 ± 0.5	20 ± 1	20.0	20 ± 1	20 ± 1
Thermal expansion coefficient	10 ⁻⁶ K ⁻¹	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5	10.8 ± 0.5

- #1: 633 nm laser
#2: Steel gauge blocks (no grade reported)
#3: Steel gauge blocks (Grade 00 or K)
#4: Gauge blocks (no statement for grade and material)
#5: Gauge blocks (Grade K, no statement for material)
#6: Steel gauge blocks (Grade 0)
#7: Ceramic gauge blocks (Grade K)





9. PERFORMANCE OF PARTICIPANTS

The *En* numbers in the tables in Section 8 show overall good performance by the majority of participating laboratories. The following is the summary of performance of participating laboratories in this interlaboratory comparison program.

<Interferometry Measurement>

Circulation group: I-1

10 laboratories were registered to participate in the interferometry measurement group (I-1). Two laboratories (Lab I1-9 & I1-10) gave up to report the results because they had troubles in measurement equipment. Lab I1-3 also had a technical problem for the interferometry measurement. It reported the results by comparison measurement method instead.

The absolute values of the *En* numbers for the measurement results on 1 mm & 8 mm gauge blocks reported by Lab I1-5 exceeded 1.

<Comparison Measurement>

Circulation group: C-1

15 laboratories were registered to participate in comparison measurement group (C-1). No result was reported from Lab C1-14.

The absolute value of the *En* numbers for the measurement results on 100 mm gauge block by Lab C1-7 and C1-10 exceeded 1. Similarly, the absolute value of the *En* number of 10 mm gauge block by Lab C1-15 exceeded 1.

Circulation group: C-2

19 laboratories participated in comparison measurement group (C-2).

The absolute value of the *En* numbers for the measurement results on 1 mm & 100 mm gauge blocks by Lab C2-5, 10 mm gauge block by Lab C2-13, 100 mm gauge block by Lab C2-18 and 100 mm gauge block by Lab C2-19 exceeded 1.

Circulation group: C-3

15 laboratories were registered to participate in comparison measurement group (C-3). No result was reported from Lab C3-9.

The absolute value of the *En* numbers for the measurement results on 10 mm gauge block by Lab C3-5, all gauge blocks by Lab C3-7, 10 mm gauge block by Lab C3-8, 100 mm gauge block by Lab C3-11 and 100 mm gauge block by Lab C3-14 exceeded 1.

Circulation group: C-4

16 laboratories were registered to participate in the comparison measurement group (C-4). No result was reported from two laboratories (Lab C4-14 & Lab C4-15).

The absolute value of the *En* numbers for the measurement results on 1 mm gauge block by Lab C4-8 and 10 mm & 100 mm gauge blocks by Lab C4-9 exceeded 1.

Circulation group: C-5

17 laboratories participated in comparison measurement group (C-5).

The absolute value of the *En* numbers for the measurement results on 1 mm & 100 mm gauge blocks by Lab C5-10 and 1 mm & 10 mm gauge blocks by Lab C5-11 exceeded 1.

10. TECHNICAL COMMENTS

10.1 Overview of Interferometry Measurement

While the measured data of the reference laboratory before circulation might have problems, those reported by the participating laboratories do not show any problem which might affect to overall evaluation of the results. Therefore, it is assumed that circulation of artefacts has been appropriately completed and the stability of artefacts during circulation was acceptable.

10.2 Overview of Comparison Measurement

The data of the reference laboratory and the participant laboratories do not show any problem which might affect to overall evaluation of the results. Therefore, it is assumed that circulation of artefacts has been appropriately completed and the stability of artefacts during circulation was acceptable.

The following factors are presumed as examples that might effect on the results of which the absolute value of *En* numbers exceeds one.

- a. influence by long term drift of reference standard
- b. influence by gauge block comparator
- c. thermal influence and deformation influence due to material difference between reference standard and the artefact
- d. miscalculation

Uncertainty of Lab C3-5 of 1 mm and 10 mm is extremely small for the measured value, which might be caused by miscalculation or mis-entry.

10.3 Uncertainty of Measurement

Measurement uncertainties reported by participating laboratories in the interferometry measurement group are consistent within the reasonable range (20 nm – 53 nm).

As for the comparison measurement groups, the preceding graphs (Section 8) show a large

variation in the magnitude of uncertainties of measurement quoted. The variation of measurement uncertainty might largely depend on the accuracy of the reference standards. For instance, Lab C4-16 reported extra large uncertainties (4.0 μm) for measurement of gauge blocks 1 mm and 10 mm with using a micrometer as the reference standard although majority of participating laboratory reported the measurement uncertainty among the range between 0.06 μm and 0.15 μm with reference gauge blocks. The difference of materials of reference gauge blocks may increase measurement uncertainties for comparison measurement.

10.4 Other Comments on the Reported Results

Reported results in the results sheet and in calibration certificates submitted from participating laboratories are investigated and compared to each other. The results of comparison are summarized in the Table E.1 of Appendix E. Followings is the summary of comments on the reported values as the results of investigation.

The measured values of 1 mm and 8 mm gauge reported by Lab I1-5 show that their absolute values of En number are more than 1 with a trend deviating towards longer (+ side) than reference values. Imperfect wringing (adherence between gauge and base plate) may be attributed to this case.

In Addition, the Lab I1-5 inquired of IAJapan for phase correction as they do not have experiences in calibration of gauge blocks provided as the artefacts. The laboratory was advised to determine the phase correction value based on the laboratories' normal procedure. Unsuccessful phase correction may result in the deviation of measurement data in a certain level.

Some entries of wrong serial number of artefacts are found in the results sheets and/or calibration certificate. Details are listed in the Table E.2 of Appendix E.

The Lab C4-16 reported its reference standard as a micrometer. The magnitude of reported uncertainties is consistent with that of measurements by the micrometer. No measurement data for 100 mm gauge was reported from this laboratory due to its measurement capability.

11. CORRECTIVE ACTION

For the purpose of this international interlaboratory comparison program, reports of corrective actions against the results determined as outliers, i.e., of which absolute values of En number are more than 1 were not requested. The root cause for outlier results may vary between the situations of measurement by participating laboratories. Primary responsibility to rectify the problem caused poor performance in this comparison program should be kept by participating laboratories and their participating accreditation bodies. Hence this report

does not contain any comments on the corrective actions reported or to be done. Just the examples of the cause are listed in the section 11 for information. The participating accreditation bodies are strongly recommended to ensure that the root causes are rectified and proper measures are put in place to prevent recurrence against poor performance of participating laboratories.

12. REFERENCE

- (1) APLAC PT001 *Calibration Interlaboratory Comparisons*, 2006
- (2) ISO *Guide to the Expression of Uncertainty in Measurement*, 1993
- (3) JIS B7506:2004 *Gauge blocks*
- (4) ISO 3650:1998 *Geometrical Product Specifications (GPS) – Length standards - Gauge blocks*
- (5) ISO Guide 43-1:1997 *Proficiency testing by interlaboratory comparisons – Part 1: Development and operation of proficiency testing schemes*

APPENDIX A

INSTRUCTIONS TO ACCREDITATION BODIES

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS INSTRUCTIONS TO ACCREDITATION BODIES

1. EQUIPMENT

On receipt, unpack the artifacts and inspect them for any defects. Please refer to **“INSTRUCTIONS TO LABORATORIES”(EQUIPMENT)** for the details of artifacts and documentations enclosed. Please note that artifacts subject to interferometry measurement and those for comparison measurement are circulated in the different exclusive circulation group respectively.

Complete the attached "**RECEIPT FORM**" and fax or Email to the organizing body, IAJapan.

Please note, these instructions and attached **Result Sheet** are master copies and must remain in the box from country to country. The national accreditation body should make copies for distribution to the participating laboratories in their country.

2. TRANSPORT

Within each economy the equipment can be carried by hand, car or by plane, whatever is considered the safest way. For transport to the next country, each participating accreditation body is asked to use a courier that will deliver “door-to-door”, that is, directly to the next accreditation body.

(1) Transportation route

Transportation of artefacts is starting from and returning to IAJapan as attached **“CIRCULATION SCHEDULE AND CONTACT LIST”**. (i.e. IAJapan → Participating ABs → IAJapan) Each participating accreditation body is obliged to ensure to receive and send artefacts to the next accreditation body. **(The last accreditation body in a circulation group of artefacts should send them back to IAJapan.)** Shipping addresses are shown on the **“CIRCULATION SCHEDULE AND CONTACT LIST”** to be attached to the artefact and will be informed by IAJapan. Participating accreditation body should arrange circulation schedule and transport for its accredited laboratories within the economy.

(2) Transportation cost

Transportation cost should be covered by each particular participating accreditation body which ship the artefacts.

3. CUSTOMS

NO ATA Carnet is provided with these artifacts. A ***Declaration to Customs Officials and Shipping Agents*** is enclosed in the plastic envelope attached to the outside of the box. Please make it is in place before dispatching to the next country otherwise it will not pass through their Customs authorities. Please attach 3 extra photocopies of the ***Declaration***.

4. MEASUREMENTS TO BE CARRIED OUT

Please refer to **INSTRUCTIONS TO LABORATORIES** enclosed. If necessary, these should be translated into the appropriate language by the accreditation body. Please refer to ISO 3650:1998 for the method of measurement.

5. CIRCULATION SCHEME

At the beginning and at the end of the circulation, measurements will be performed by the following reference laboratories:

For Interferometry measurement group, National Metrology Institute of Japan (NMIJ);
For comparison measurement group, Mitutoyo Corporation

It is the responsibility of the participating accreditation body to make sure that the artifacts are dispatched to the next participant by the date specified. Two weeks have been allowed for each international transport and customs clearance. If a delay occurs with one laboratory then the number of participating laboratories in that country will have to be reduced so that the artifacts leave by the scheduled date. When ready for dispatch, fill in the attached **DISPATCH FORM** and fax or Email to the next participant and to IAJapan (organizing body).

6. DOCUMENTS TO BE SUBMITTED

Within two weeks of the completion of the measurements, participating laboratories are required to send the **Result Sheet, Surface Condition Report of Gauge Blocks^{*)} and their Calibration Certificate** by fax or Email to their accreditation body. No other documentation is required. The accreditation body is required to ensure that the *Result Sheet, Surface Condition Report of Gauge Blocks* and *Calibration Certificate* have been filled in correctly and completely. The accreditation body should provide details of any problems that their laboratories had to IAJapan. The accreditation body is required to fax or Email the documentation to IAJapan within two weeks of dispatching the artifacts.

A final report will be issued at the end of the program with each laboratory only identified by a **confidential** code number. IAJapan will send the final report to each Accreditation Body. (Interim report will not be issued.)

*) Laboratories are required to submit *Surface Condition Report of Gauge Blocks* twice, i.e. (i) when they receive the artefact and (ii) when it submit the results of measurement to Accreditation Body. Accreditation Bodies are required to send these two **Surface Condition Report of Gauge Blocks** with **Result Sheet and Calibration Certificate** to IAJapan.

7. GENERAL INFORMATION

For general queries, please contact:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

RECEIPT FORM
APLAC INTERLABORATORY COMPARISON
APM018 – Short Gauge Blocks

In order to monitor the progress of the interlaboratory comparison, we kindly ask each accreditation body, on receipt of the artifacts, to fill in this **RECEIPT FORM** and fax or Email it to:

Mr. Yoshinobu UEMATSU

Technical Manager,
International Accreditation Japan (IAJapan)
National Institute of Technology and Evaluation (NITE)
2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan
Phone No.: +81-3-3481-1939 Fax No.: +81-3-3481-1937
E-mail Address: uematsu-yoshinobu@nite.go.jp

Thank you in advance for your cooperation.

The APM018 artifacts were received on: _____(date)

After inspection, are the contents damaged? _____(Yes/no)

If yes, is this serious? _____(Yes/no)

Are the contents still suitable for use? _____(Yes/no)

Was there a "**Declaration to Customs Officials and Shipping Agents**" enclosed in the plastic envelope attached to the outside of the case? _____(Yes/no)

Remarks: _____

Participating Accreditation Body: _____

Contact Person: _____

Circulation Group: _____ **Fax:** _____

DISPATCH FORM
APLAC INTERLABORATORY COMPARISON
APM018 – Short Gauge Bloks

In order to monitor the progress of the interlaboratory comparison, we kindly ask each accreditation body, on dispatch of the artifacts, to fill in this **DISPATCH FORM** and fax or e-mail it to:-

Mr. Yoshinobu UEMATSU

Technical Manager,
International Accreditation Japan (IAJapan)
National Institute of Technology and Evaluation (NITE)
2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan
Phone No.: +81-3-3481-1939 Fax No.: +81-3-3481-1937
E-mail Address: uematsu-yoshinobu@nite.go.jp

And **also** fax or e-mail it to the **next participating accreditation body:-**

Name : _____

Accreditation body: _____

Fax: _____

Please ensure that the "***Declaration to Customs Officials and Shipping Agents***" is attached to the outside of the case. Thank you in advance for your cooperation.

The APM018 artifacts were dispatched on: _____(date)

The artifacts have been inspected after return from our laboratories and were found to be in good condition. _____(Yes/no)

Please give details of any problems:-

Shipping agent: _____ Phone: _____ Fax: _____

Airway bill no. (or consignment note no.): _____

You accreditation body: _____

Contact person: _____ Fax: _____

Circulation Group: _____

APPENDIX B

INSTRUCTIONS TO LABORATORIES

CONTENTS

- (1) INSTRUCTION FOR INTERFEROMETORY MEASUREMENT (Circulation Group: I-1)
- (2) INSTRUCTION FOR CONPARIOSON MEASUREMENT (Circulation Group: C-1)
- (3) INSTRUCTION FOR CONPARIOSON MEASUREMENT (Circulation Group: C-2)
- (4) INSTRUCTION FOR CONPARIOSON MEASUREMENT (Circulation Group: C-3)
- (5) INSTRUCTION FOR CONPARIOSON MEASUREMENT (Circulation Group: C-4)
- (6) INSTRUCTION FOR CONPARIOSON MEASUREMENT (Circulation Group: C-5)

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for Interferometry Measurement

(Circulation Group: **I-1**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Interferometry measurement I-1	Gauge Block	00272	Nominal length: 1 mm Material: Steel Manufacturer: Tsugami Precision Co Ltd Grade: K (JIS B 7506:2004) Thermal expansion coefficient: $10.9 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	00272	Nominal length: 8 mm Material: Steel Manufacturer: Tsugami Precision Co Ltd Grade: K (JIS B 7506:2004) Thermal expansion coefficient: $10.9 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	00272	Nominal length: 75 mm Material: Steel Manufacturer: Tsugami Precision Co Ltd Grade: K (JIS B 7506:2004) Thermal expansion coefficient: $10.9 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results obtained by the interferometry measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Interferometry)

Name of participant:

Circulation group:

Date of measurement:

Environment: Temperature

Humidity

Reference standard (type, S/N, wavelength):

Outlines of Phase Correction:

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Measuring face of the gauge block wrung during measurement	Remarks
1						
8						
75						

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference ambient condition (Refer to ISO 3650:1998): temperature $t_o = 20^\circ\text{C}$, atmospheric pressure 101325 Pa
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks $(10.9 \pm 0.1) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Interferometry Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

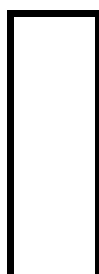
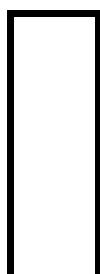
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/No.:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 8 mm (S/No.:)

Please indicate the position of damage (such as scratch and rust) .

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

Nominal length: 75 mm (S/No.:)

Please indicate the position of damage. (such as scratch and rust)

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

NOTE: Photograph may be helpful as the supplement for the description of damage.

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for

Comparison Measurement

(Circulation Group: **C-1**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Comparison Measurement C-1	Gauge Block	000646	Nominal length: 1 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	997507	Nominal length: 10 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	001494	Nominal length: 100 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results by comparison measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Comparison)

Name of participant:

Circulation Group:

Date of measurement:

Environment:

Temperature

Humidity

Reference standard (type, S/N, Material):

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Remarks
1					
10					
100					

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference temperature $t_0 = 20^\circ\text{C}$ (Refer to ISO 3650:1998)
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks: $(10.8 \pm 0.5) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

 Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Comparison Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

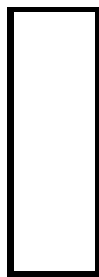
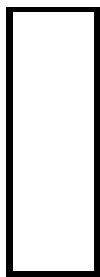
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 10 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) .

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

Nominal length: 100 mm (S/N:)

Please indicate the position of damage. (such as scratch and rust)

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

NOTE: Photograph may be helpful as the supplement for the description of damage.

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for

Comparison Measurement

(Circulation Group: **C-2**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Comparison Measurement C-2	Gauge Block	040816	Nominal length: 1 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	001297	Nominal length: 10 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	001480	Nominal length: 100 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results by comparison measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Comparison)

Name of participant:

Circulation Group:

Date of measurement:

Environment:

Temperature

Humidity

Reference standard (type, S/N, Material):

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Remarks
1					
10					
100					

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference temperature $t_0 = 20^\circ\text{C}$ (Refer to ISO 3650:1998)
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks: $(10.8 \pm 0.5) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

 Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Comparison Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

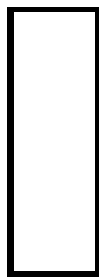
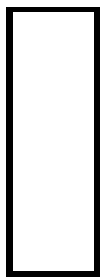
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



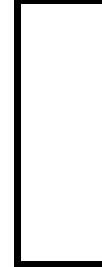
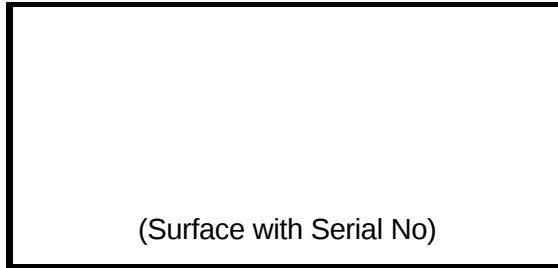
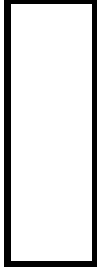
(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 10 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) .



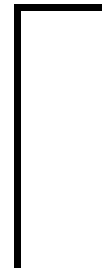
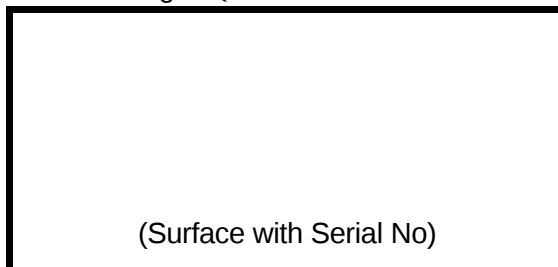
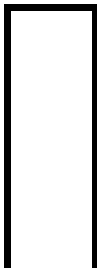
(Surface with Serial No)

Please describe details of damage below.

[]

Nominal length: 100 mm (S/N:)

Please indicate the position of damage. (such as scratch and rust)



(Surface with Serial No)

Please describe details of damage below.

[]

NOTE: Photograph may be helpful as the supplement for the description of damage.

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for

Comparison Measurement

(Circulation Group: **C-3**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Comparison Measurement C-3	Gauge Block	000487	Nominal length: 1 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	006531	Nominal length: 10 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	993050	Nominal length: 100 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results by comparison measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Comparison)

Name of participant:

Circulation Group:

Date of measurement:

Environment:

Temperature

Humidity

Reference standard (type, S/N, Material):

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Remarks
1					
10					
100					

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference temperature $t_0=20\text{ }^{\circ}\text{C}$ (Refer to ISO 3650:1998)
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks: $(10.8 \pm 0.5) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

 Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Comparison Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

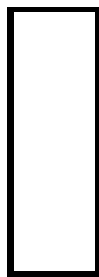
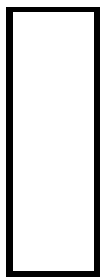
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



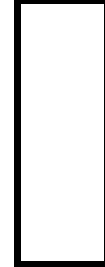
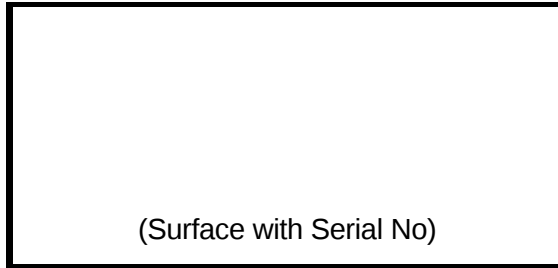
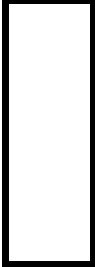
(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 10 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) .



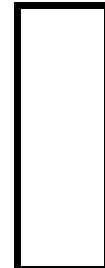
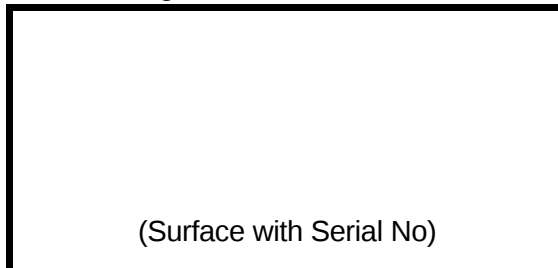
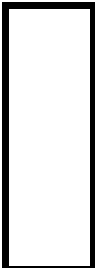
(Surface with Serial No)

Please describe details of damage below.

[]

Nominal length: 100 mm (S/N:)

Please indicate the position of damage. (such as scratch and rust)



(Surface with Serial No)

Please describe details of damage below.

[]

NOTE: Photograph may be helpful as the supplement for the description of damage.

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for

Comparison Measurement

(Circulation Group: **C-4**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Comparison Measurement C-4	Gauge Block	040325	Nominal length: 1 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	003005	Nominal length: 10 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	000759	Nominal length: 100 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results by comparison measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

Phone No.: +81-3-3481-1939

Fax No.: +81-3-3481-1937

E-mail Address: uematsu-yoshinobu@nite.go.jp

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Comparison)

Name of participant:

Circulation Group:

Date of measurement:

Environment:

Temperature

Humidity

Reference standard (type, S/N, Material):

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Remarks
1					
10					
100					

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference temperature $t_0=20\text{ }^{\circ}\text{C}$ (Refer to ISO 3650:1998)
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks: $(10.8 \pm 0.5) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Comparison Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

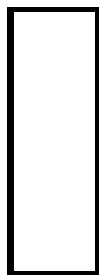
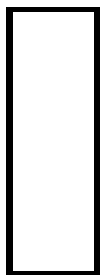
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 10 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) .

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

Nominal length: 100 mm (S/N:)

Please indicate the position of damage. (such as scratch and rust)

	(Surface with Serial No)	
--	--------------------------	--

Please describe details of damage below.

--

NOTE: Photograph may be helpful as the supplement for the description of damage.

APLAC INTERLABORATORY COMPARISON APM018 – SHORT GAUGE BLOCKS

INSTRUCTIONS TO LABORATORIES for

Comparison Measurement

(Circulation Group: **C-5**)

1. EQUIPMENT

Equipment and Accessories List

Group	Content	S/N	Specification
Comparison Measurement C-5	Gauge Block	040400	Nominal length: 1 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	006510	Nominal length: 10 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Gauge Block	001498	Nominal length: 100 mm Material: Steel Manufacturer: Mitutoyo Corporation Grade: 0 (JIS B 7506: 2004) Thermal expansion coefficient: $10.8 \times 10^{-6} \text{ K}^{-1}$
	Container of GBs	-	Timber case for GBs
	Transit Case	-	Duralumin made transportation case

Documentation

Name of Document	Number of copy
DECLARATION TO CUSTOMS OFFICIALS AND SHIPPING AGENTS	4
CIRCULATION SCHEDULE AND CONTACT LIST	1
INSTRUCTIONS TO ACCREDITATION BODIES	1
INSTRUCTIONS TO LABORATORIES	1
RESULT SHEET	1
SURFACE CONDITION REPORT OF GAUGE BLOCKS	1
RECEIPT FORM	1
DISPATCH FORM	1

On receipt, unpack the artefacts and inspect them for any defects. Make sure to sketch surface condition of all the artefacts on the “**Surface Condition Report of Gauge Blocks**”.

Send Surface Condition Report of Gauge Blocks by fax or e-mail right away to your accreditation body.

The measurement surface should never be relapped or polished.

2. TRANSPORT OF ARTEFACT

The artifacts can be carried by hand, car or by plane, whatever is considered the safest way. Please follow the instructions provided by your accreditation body if it has.

3. MEASUREMENTS TO BE CARRIED OUT

3.1 Preparation

Remove the timber container from transit case and place it in the test bench under the condition of your accredited procedures. It is advisable to leave the timber case opened overnight to ensure that all gauge blocks have settled to the ambient laboratory temperature.

3.2 Measurement

The length at the center point of the end surface of the gauge blocks should be measured. All measurement should be done in accordance with your accredited procedures.

NOTE: "ISO 3650:1998, Geometrical Product Specifications (GPS) – Length standards – Gauge blocks" and equivalent national standard can be used as a reference document.

After measurement, you must give rust proof treatment the on each gauge block and contain them into the timber case.

4. DOCUMENTS TO BE SUBMITTED

Within **two weeks** of the completion of the measurements, participating laboratories are required to send the attached **Result Sheet** ^{*1)}, **Surface condition report of Gauge Blocks**^{*2)} and **the calibration certificate** to their accreditation body. No other documents are required. Laboratories should make a copy of the *Result Sheet* for their own records.

Where possible, uncertainties should be calculated using the method in the *ISO Guide to the Expression of Uncertainty in Measurement*.

*1) Please use Attachment 1 for the results by comparison measurement method.

*2) Please make sure that all defects of the surface of the artefacts be sketched in the Surface Condition Report of Gauge Blocks after measurement and submit it to the accreditation body with other documentation.

5. GENERAL INFORMATION

For general queries, please contact your accreditation body. Additional information may be obtained from the program coordinator below:

Yoshinobu UEMATSU

Technical Manager

International Accreditation Japan (IAJapan)

National Institute of Technology and Evaluation (NITE)

2-49-10, Nishihara, Shibuya-ku, Tokyo 151-0066, Japan

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APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

RESULTS SHEET (Comparison)

Name of participant:

Circulation Group:

Date of measurement:

Environment:

Temperature

Humidity

Reference standard (type, S/N, Material):

Name of accreditation body:

Results:

Nominal length (mm)	Gauge S/N	Deviation of central length from nominal $I_c - I_n$ (μm)	Measurement uncertainty U (μm)	Coverage factor k	Remarks
1					
10					
100					

NOTE:

- Deviation of central length from nominal shall be reported as a value at the reference temperature $t_0 = 20^\circ\text{C}$ (Refer to ISO 3650:1998)
 I_c : Central Length I_n : Nominal Length
- Measurement uncertainty (U) shall be reported by using expanded uncertainty.
- Coverage factor shall be a value which defines an interval having a level of confidence of approximately 95 % (Typically, $k=2$).
- Thermal expansion coefficient of gauge blocks: $(10.8 \pm 0.5) \times 10^{-6}/\text{K}$
 If the expansion coefficient other than the above is used, please report it in the relevant column of Remarks.
- Enter "N/A", if it is not applicable.
- Only one value should be entered for each column of the measured data.
- Use SI unit only.

Signature of responsible person: _____

 Date: / /
 dd mm yyyy

APLAC INTERLABORATORY COMPARISON APM018 - Short Gauge Blocks

SURFACE CONDITION REPORT OF GAUGE BLOCKS

(for Comparison Measurement)

Date:

Name of participant:

Circulation Group:

Name of responsible person:

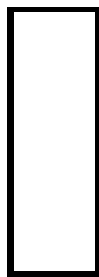
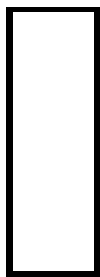
Name of accreditation body:

Please mark: (i) on receipt (ii) after measurement

Gauge block (nominal length: 1 mm)

Nominal length: 1 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) and describe details of damage in the bracket below.



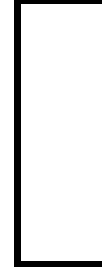
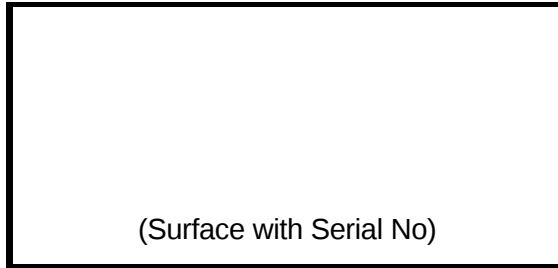
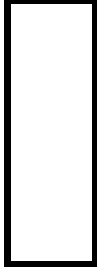
(surface with Serial No)



Gauge blocks (nominal length: other than 1 mm)

Nominal length: 10 mm (S/N:)

Please indicate the position of damage (such as scratch and rust) .



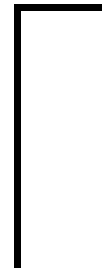
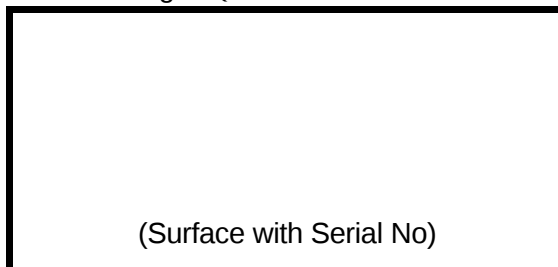
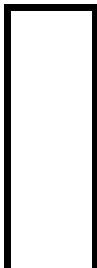
(Surface with Serial No)

Please describe details of damage below.

[]

Nominal length: 100 mm (S/N:)

Please indicate the position of damage. (such as scratch and rust)



(Surface with Serial No)

Please describe details of damage below.

[]

NOTE: Photograph may be helpful as the supplement for the description of damage.

APPENDIX C

CIRCULATION TIME SCHEDULE

CIRCULATION TIME SCHEDULE

1. Interferometry Measurement Group

Table C1 – Circulation Group I-1

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	NMIJ (Ref Lab)			
Japan	IAJapan	11 July 2005	4 August 2005	2
Czech	CAI	15 August 2005	6 September 2005	1
UK	UKAS	not reported	5 October 2005	1
USA	NVLAP	11 October 2005	9 November 2005	1
USA	ACLASS	11 November 2005	20 December 2005	0(1)
Mongolia	MASM	30 December 2005	18 January 2006	1
China	CNAL	28 January 2006	17 February 2006	1
Malaysia	DSM	20 February 2006	not reported	1
Argentina	OAA	not reported	not reported	0(1)
Japan (Ref)	NMIJ (Ref Lab)			
			Total Labs =	8(2)

* The number inside of the parenthesis indicates the number of laboratories that had been registered but did not actually participate, and excluded from the number of participants.

2. Comparison Measurement Group

Table C2 - Circulation Group C-1

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	MITUTOYO (Ref Lab)			
Japan	IAJapan	11 July 2005	11 August 2005	4
Korea	KOLAS	16 August 2005	10 October 2005	2(1)
Hong Kong	HKAS	13 October 2005	not reported	2
Philippine	BPSLAS	2 December 2005	19 January 2006	1
China	CNAL	23 January 2006	15 February 2006	2
Taiwan	CNLA	17 February 2006	6 April 2006	3
Japan (Ref)	MITUTOYO (Ref Lab)			
			Total Labs =	14(1)

* The number inside of the parenthesis indicates the number of laboratories that had been registered but did not actually participate, and excluded from the number of participants.

2. Comparison Measurement Group (cont.)

Table C3 - Circulation Group C-2

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	MITUTOYO (Ref Lab)			
Vietnam	VILAS	14 July 2005	24 August 2005	2
Singapore	SAC	not reported	not reported	4
Thailand	TISI	29 September 2005	not reported	4
Indonesia	KAN	not reported	6 January 2006	3
India	NABL	9 January 2006	21 February 2006	3
Pakistan	PNAC	not reported	1 April 2006	3
Japan (Ref)	MITUTOYO (Ref Lab)			
			Total Labs =	19

Table C4 - Circulation Group C-3

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	MITUTOYO (Ref Lab)			
Australia	NATA	12 July 2005	24 August 2005	3
New Zealand	IANZ	25 August 2005	19 September 2005	2
USA	NVLAP	28 September 2005	9 November 2005	1(1)
USA	A2LA	10 November 2005	12 January 2006	3
Canada	CLAS	26 January 2006	24 February 2006	3
Malaysia	DSM	3 March 2006	3 April 2006	2
Japan (Ref)	MITUTOYO (Ref Lab)			
			Total Labs =	14(1)

* The number inside of the parenthesis indicates the number of laboratories that had been registered but did not actually participate, and excluded from the number of participants.

2. Comparison Measurement Group (cont.)

Table C5 - Circulation Group C-4

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	MITUTOYO (Ref Lab)			
Mexico	ema	21 July 2005	19 August 2005	3
Chile	INN	23 August 2005	27 September 2005	2
Brazil	INMETRO	18 October 2005	22 November 2005	3
USA	ACLASS	28 November 2005	17 January 2006	3
Cuba	ONARC	not reported	10 April 2006	1
Argentina	OAA	26 April 2006	6 June 2006	2
Benz era	SENCAMAER	The artefacts were not sent.	-	0(2)
Japan (Ref)	MITUTOYO (Ref Lab)			
			Total Labs =	14(2)

* The number inside of the parenthesis indicates the number of laboratories that had been registered but did not actually participate, and excluded from the number of participants.

Table C6 - Circulation Group C-5

ECONOMY	ACCREDITATION BODY	RECEIPT	DISPATCH	NO. OF LABS
Japan (Ref)	MITUTOYO (Ref Lab)			
Czech	CAI	2 August 2005	29 August 2005	2
UK	UKAS	not reported	5 October 2005	2
Sweden	SWEDAC	10 October 2005	not reported	2
Belgium	BELAC	10 November 2005	21 December 2005	3
Portugal	IPAC	not reported	21 February 2006	3
Israel	ISRAC	not reported	not reported	5
Japan (Ref)	MITUTOYO (Ref Lab)			
			Total Labs =	17

3. Total Number of participating Laboratories

Interferometry Measurement: 8 Laboratories from 7 ABs

Comparison Measurement: 78 Laboratories from 30 ABs

APPENDIX D

ARTEFACTS STABILITY

1. INTERFEROMETRY MEASUREMENT

Table D1 – Stability Interferometry Measurement group (I-1)

Reference Laboratory: NMIJ

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1		+0.014		0.017
8		+0.008		0.017
75	-0.058	-0.049	-0.009	0.024

2. COMPARISON MEASUREMENT

Table D2 – Stability Comparison Measurement group(C-1)

Reference Laboratory: Mitutoyo

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1	+0.051	+0.052	-0.001	0.030
10	-0.034	-0.033	-0.001	0.030
100	+0.066	+0.046	-0.020	0.030

Table D3 – Stability Comparison Measurement group(C-2)

Reference Laboratory: Mitutoyo

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1	+0.019	+0.027	-0.008	0.030
10	+0.008	+0.008	0.000	0.030
100	-0.082	-0.097	+0.015	0.030

Table D4 – Stability Comparison Measurement group(C-3)

Reference Laboratory: Mitutoyo

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1	+0.022	+0.028	-0.006	0.030
10	-0.030	-0.024	-0.006	0.030
100	+0.093	+0.071	+0.022	0.030

Table D5 – Stability Comparison Measurement group(C-4)

Reference Laboratory: Mitutoyo

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1	+0.014	+0.032	-0.018	0.030
10	-0.025	-0.028	+0.003	0.030
100	-0.012	-0.034	+0.022	0.030

Table D6 – Stability Comparison Measurement group(C-5)

Reference Laboratory: Mitutoyo

Nominal Length of Gauge Block (mm)	Value of Before circulation V_b (μm)	Value of After circulation V_a (μm)	$V_b - V_a$ (μm)	Expanded uncertainty ($k=2$) (μm)
1	-0.009	-0.010	+0.001	0.030
10	-0.015	-0.019	+0.004	0.030
100	+0.063	+0.050	+0.013	0.030

APPENDIX E

COMMENTS ON THE REPORTED RESULTS

Comments on the Reported Results

As mentioned in 10.4, reported results and calibration certificates were investigated. The following is the summary of comments on the reported results and the contents of the calibration certificates.

1. Difference of the reported results in the results sheets and in the calibration certificate

There are a number of cases that reported data in the results sheets are different from those in the calibration certificate. Table E1 shows the details of the differences.

Table E1 – Difference of reported results

Data	Lab	Values in the certificate	Values in the result sheet
Measured data	I1-1	1 mm: +0.039 μm , 75 mm: -0.053 μm	1 mm: +0.038 μm , 75 mm: -0.052 μm
	II-4	1 mm: -0.03 μm , 8 mm: -0.01 μm , 75 mm: -0.08 μm	1 mm: -0.029 μm , 8 mm: -0.010 μm , 75 mm: -0.084 μm
	C3-15	1 mm: 0.02 μm , 10 mm: -0.02 μm , 100 mm: 0.12 μm	1 mm: 2 μm , 10 mm: -2 μm , 100 mm: 12 μm
	C4-12	1 mm: +0.04 μm 10 mm: -0.11 μm 100 mm: -0.01 μm	1 mm: +0.040 μm 10 mm: -0.110 μm 100 mm: -0.010 μm
Measurement uncertainty	C1-4	1 mm: $(0.05+1.2 \cdot L) \mu\text{m}$ = 0.0512 μm , 10 mm: $(0.05+1.2 \cdot L) \mu\text{m}$ = 0.062 μm	1 mm: 0.06 μm , 10 mm: 0.07 μm
	C1-6	1 mm: 0.16 μm 10 mm: 0.16 μm	1 mm: 0.09 μm 10 mm: 0.09 μm
	C1-11	1 mm: 0.20 μm	1 mm: 0.21 μm
	C2-15	1 mm: 0.3 μm 10 mm: 0.3 μm 100 mm: 0.5 μm	1 mm: 0.18 μm 10 mm: 0.18 μm 100 mm: 0.43 μm
	C3-7	$(0.040+0.0005 \cdot L) \mu\text{m}$ or 0.05 μm , Whichever greater <1 mm, 10 mm: 0.05 μm >	1 mm: 0.041 μm , 10 mm: 0.045 μm
	C3-12	10 mm: 0.12 μm	10 mm: 0.16 μm
	C3-15	$(2.9+0.87 \cdot L) \mu\text{in}$	1 mm: 0.074 μm , 10 mm: 0.082 μm , 100 mm: 0.161 μm
	C4-12	1 mm: 0.09 μm 10 mm: 0.09 μm	1 mm: 0.080 μm 10 mm: 0.080 μm

		100 mm: 0.12 μm	100 mm: 0.120 μm
	C5-9	Gauges up to & including 10 mm: 0.08 μm	10 mm: 0.010 μm
Coverage factor	C1-4	$k = 2$	$k = 1.99$
	C1-15	<i>No statement of coverage factor in the calibration certificate</i>	1 mm: $k = 2.20$ 10 mm: $k = 2.11$ 100 mm: $k = 1.98$
	C2-14	<i>No statement of coverage factor in the calibration certificate</i>	<i>No coverage factor reported</i>
	C3-3	$k = 2.0$	1 mm: $k = 2.01$ 10 mm: $k = 2.01$ 100 mm: $k = 2.02$

Table E.2 - List for incorrect serial numbers of the artefacts reported

Lab	Reported serial No.	Correct serial No.
C2-5	Serial No. 001488 was entered for 100 mm gauge in both results sheet and calibration certificate.	Correct serial No.: 001480
C4-4	Serial No. 000739 was entered for 100 mm gauge in the calibration certificate.	Correct serial No.: 000759
C4-12	Serial No. 050325 was entered for 1 mm gauge in the calibration certificate.	Correct serial No.: 040325
C5-10	Serial No. 004510 was entered for 10 mm gauge in both results sheet and calibration certificate.	Correct serial No.: 006510