



National Institute of Metrology (Thailand)

Report on APMP Bilateral Comparison
Measurement of long gauge blocks by comparative
method

APMP.L-S6

Final Report

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1 Document control

- Version Draft B.1 Issued on August 2014.
- Version Draft B.2 Issued on February 2015, comments from participants taken into account.
- Version Draft B.3 Issued on December 2015, comments from APMP TCL taken into account.

2 Introduction

The metrological equivalence of national measurement standards and of calibration certificates issued by national metrology institutes is established by a set of key and supplementary comparisons chosen and organized by the Consultative Committees of the CIPM or by the regional metrology organizations in collaboration with the Consultative Committees.

The procedures outlined in this document cover the technical procedure to be followed during the measurements. A goal of the APMP key comparisons for topics in dimensional metrology is to demonstrate the equivalence of routine calibration services offered by NMIs to clients, as listed in Appendix C of the Mutual Recognition Agreement (MRA). To this end, participants in this comparison agree to use the same apparatus and methods as routinely applied to client artefacts.

By their declared intention to participate in this key comparison, laboratories accept the general instructions and to strictly follow the technical protocol. The allocated time periods are not only for measurements, but also for the transportation and customs clearance.

3 Organization

3.1 Participants

Table 1. List of involved laboratories and their contacts.

Position	Laboratory Code	Contact person, Laboratory	Phone, Fax, email
Pilot	NIMT	Mr. Pawat Phuaknoi National Institute of Metrology Thailand 3/4-5 Moo 3, Klong 5, Klong Luang, Pathumthani 12120 Thailand	Tel. +66 5775100 ext. 1216 Fax. +66 5775088 e-mail: pawat@nimt.or.th
Participant	KRISS	Dr. Tae Bong Eom Korea Research Institute of Standards and Science, 267 Gajeong-Ro, Yuseong-Gu, Daejeon 34113, Rep. of Korea	Tel. +82 42-868-5108 Fax +82 42-868-5608 e-mail: tbeom@kriss.re.kr
Neutral	NMIJ	Dr. Toshiyuki Takatsuji National Metrology Institute of Japan AIST 3, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8563, Japan	Tel. +81-29-861-4361 Fax +81-29-861-4152 e-mail: Toshiyuki.Takatsuji@aist.go.jp

3.2 Schedule

The participating laboratories were asked to specify a preferred timetable slot for their own measurements of the gauge blocks – the timetable given in table 2 has been drawn up taking these preferences into account. Each laboratory has one month that include customs clearance, calibration and transportation to the following participant. With its confirmation to participate, the laboratory is obliged to perform the measurements in the allocated period and to allow enough time in advance for transportation so that the following participant receives them in time. In order to confirm the stability of the artefact, the start of the measurement was delayed by one month.

Table 2. Schedule of the comparison.

APMP	Laboratory	Original Schedule	Actual Schedule
Pilot	NIMT-1	June 2013	July 2013
Participant	KRISS	July 2013	August 2013
Pilot	NIMT-2	August 2013	October 2013

4 Artefacts

4.1 Description of artefacts

The package contains 3 gauge blocks. The gauge blocks are of rectangular cross section and comply with the calibration grade 0 of the standard ISO 3650:1998. Note: the gauge blocks were selected for good quality of the faces and small variation in length, the limit deviation t_e from nominal length may not be met by some of the artefacts.

The coefficients of thermal expansion given in the following table are obtained from the manufacturer and were used as such for compensations.

Table 3. List of artefacts.

Identification	Nominal length /mm	Expansion coefficient / 10^{-6} K^{-1}	Manufacturer
930608	150	10.8 ± 1.0	Mitutoyo
930154	250	10.8 ± 1.0	Mitutoyo
922002	500	10.8 ± 1.0	Mitutoyo

4.2 Stability of artefacts

Steel gauge blocks occasionally show a growing or a shrinkage the rate of which is approximately linear with time. The instability of the blocks was determined in course of the comparison. For this check the measurements of the pilot laboratory are used exclusively, not that of the other participant. According to these data in Table 4, the drift was negligible compared to the measurement uncertainty and the gauge blocks are considered stable.

Table 4. Stability result of gauge blocks.

Nominal Length mm	Id number	Jul-13		Oct-13		Drift nm
		Deviation, nm	Uncertainty $k = 2$, nm	Deviation, nm	Uncertainty $k = 2$, nm	
150	930608	340	120	330	120	-10
250	930154	-140	160	-160	160	-20
500	922002	-880	280	-880	280	0

The observed length change is significantly smaller than its uncertainty. The gauge block is considered stable and no modification to the standard evaluation procedure will be applied.

4.3 Condition of artefacts at start/end of comparison

A wooden case for the long gauge blocks is used for the transportation of the artefacts (Figure 1). Upon reception of the package, the laboratory has to check that the content is complete and that there is no apparent damage on the box or any of the standards. The reception has to be confirmed immediately to the pilot with a copy to the former participant (sender), preferably using the form as in the Appendix A of the protocol.

The organization costs were covered by the pilot laboratory, which include the standards themselves, the case and packaging, and the shipping costs to the next laboratory. The pilot laboratory has no insurance for any loss or damage of the standards during the circulation.



Figure 1. Transporting case

Once the measurements have been completed, the package shall be sent to the following participant. The steel gauge blocks need to be protected against corrosion when not being measured by means of protective oil. The sketches of the gauge block surfaces before and after comparison are illustrated in Figure 2 and 3, respectively. The “A” surface is the right hand measuring face of the gauge blocks. It should be addressed that although there are scratches on the surface of gauge blocks, the flatness quality is within their specifications and ISO 3650:1998. Also, after the bilateral comparison, there is no significant change in quality of gauge blocks’ surface. Hence, one can conclude that no damage, severe scratches or rust that may affect the measurement result, is occurred during the comparison.

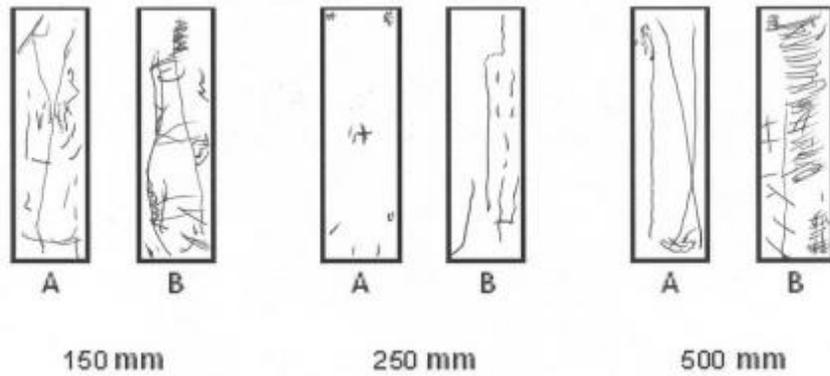


Figure 2. Sketches of the gauge blocks before comparison.

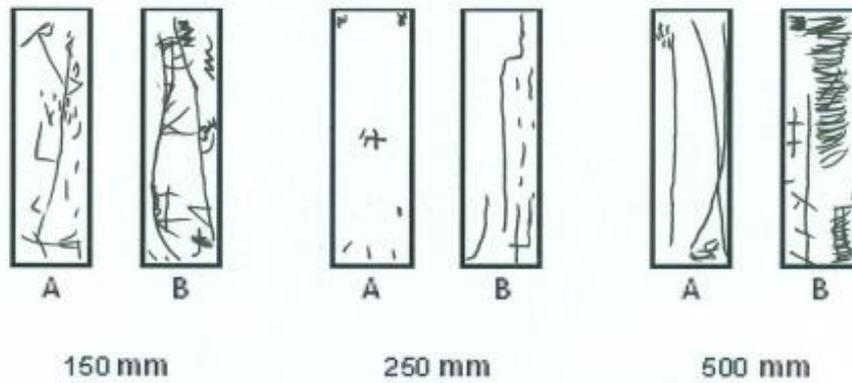


Figure 3. Sketches of the gauge blocks after comparison.

5 Measuring instructions

The gauge blocks were to be measured based on the standard procedure that the laboratory regularly uses for this calibration service for its customers. The measurand is the deviation e_c of the central length l_c from the nominal length l_n of a gauge block, $e_c = l_c - l_n$.

6 Results

All participants submitted their measurement report to the neutral laboratory, NMIJ, within four weeks at the latest. The measurement conditions of participants are listed in Table 5 and the numerical results are summarized in Table 6. Figure 4 illustrates the graphical representation of the results.

Table 5. Measurement conditions of participants.

Lab	NIMT	KRISS
Type and model of comparator	Type : Comparator using two contacting probe Model : 828 CiM	Type : Comparator using two contacting probe Model : 130B-16
Manufacturer, Tip radius and Measuring force of probe	MFR : Mahr Tip radius : 1 mm Measuring force : 1N	MFR : Mahr federal Tip radius : 3.2 mm Measuring force : Upper 1.1 N Lower 0.6 N
Manufacturer, material and CTE of standard gauge blocks	MFR : Koba Material : Steel CTE: $11.5 \times 10^{-6}/K$, $11.0 \times 10^{-6}/K$	MFR : Mitutoyo Material : Steel CTE : $10.8 \times 10^{-6}/K$
Temperature range	20.0 °C ± 0.3 °C (Room temperature) Temperature difference of gauge blocks is 0.03 °C	19.88 °C - 20.10 °C
Measurement method and traceability	Comparative method with standard gauge blocks (grade K of the same nominal length, and the same material)	Comparative method with standard gauge blocks (grade K of the same nominal length, and the same material)

Table 6. Deviation (x) and expanded uncertainty at $k = 2$ reported by the laboratories.

Identification	Deviation from nominal length / μm					
	150 mm (930608)		250 mm (930154)		500 mm (922002)	
Lab	x	$U (k=2)$	x	$U (k=2)$	x	$U (k=2)$
NIMT	0.340	0.120	-0.140	0.160	-0.880	0.280
KRISS	0.345	0.059	-0.165	0.085	-0.553	0.172

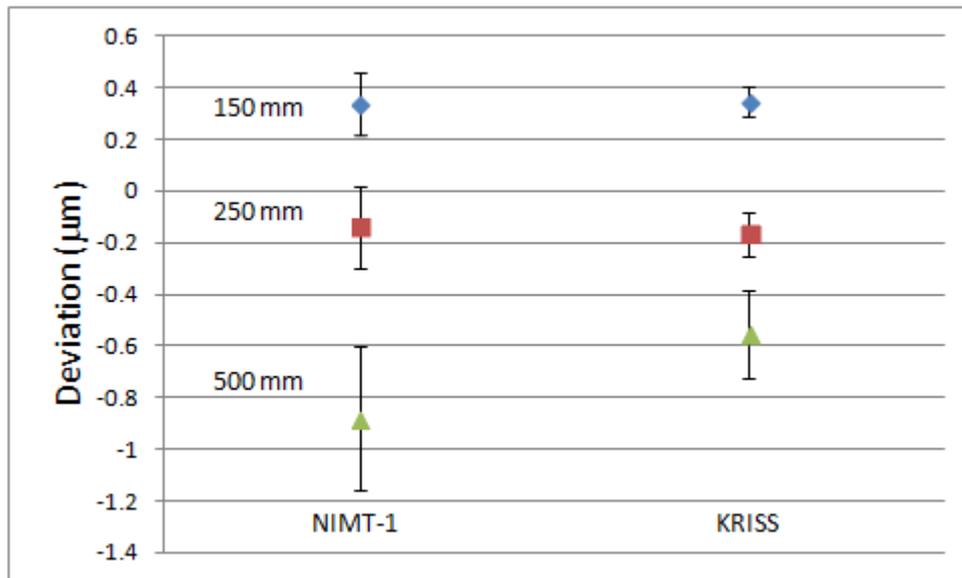


Figure 4. Reported measurement results. Error bars indicate expanded uncertainty at $k = 2$.

7 Analysis

For each laboratory's result, the E_n value is calculated. E_n is defined as the absolute value of the difference in participants' measured values, divided by the expanded uncertainty of this difference. Table 7 lists the the E_n values for each gauge block.

$$E_n = \frac{|x_1 - x_2|}{\sqrt{U^2(x_1) + U^2(x_2)}}$$

Table 7. Degrees of equivalence, associated with the expanded uncertainties with $k = 2$.

Nominal Length, mm	ID No.	E_n
150	930608	0.037
250	930154	0.138
500	922002	0.995

8 Conclusion

The bilateral comparison for long gauge block calibration using comparative method was conducted. Three gauge blocks were used as artefact with length of 150 mm, 250 mm and 500 mm. The gauge blocks were examined before and after despatch and no significant damage was occurred during the measurement. The participants performed measurement according to their routine calibration procedure which is normally used to provide calibration service to the customer. All reported measurement results from the two participants agree well with $En < 1$.

KRISS had participated in the APMP.L-K2: Calibration of long gauge blocks and hence this comparison and the regional key comparison can be linked.

9 References

[1] ISO 3650 Geometrical Product Specifications (GPS) -- Length standards -- Gauge blocks, Geneva, Switzerland, 1998.

[2] Evaluation of measurement data - Guide to the expression of uncertainty in measurement (GUM), JCGM 100.2008 GUM 1995 with minor corrections, International Organization for Standardization, Geneva, Switzerland, 2008.

[3] ISO/IEC 17043 Conformity assessment – General requirements for proficiency testing, International Organization for Standardization, Geneva, Switzerland, 2010.

[4] M.G. Cox, "The Evaluation of Key Comparison Data", Metrologia, 2002, 39, 589-595.