Key Comparison EURAMET.L-K1.2011
Calibration of Gauge Blocks by Interferometry
EURAMET Project Nr.: 1218

Instructions and Technical Protocol

3rd Amandment

BEV - Bundesamt für Eich- und Vermessungswesen

BEV
Bundesamt für Eich- und Vermessungswesen

Content

1. Introduction

The metrological equivalence of national measurement standards will be determined by a set of key comparisons chosen and organized by the Consultative Committees of the CIPM working closely with the Regional Metrology Organizations (RMOs). At its meeting in September 2008, the Consultative Committee for Length, CCL, identified several key comparisons in the field of dimensional metrology. In particular, it decided that the formally individual key comparison on short gauge blocks and on length bars (long gauge blocks) should be combined under the designation CCL-K1.

The key comparison detailed in this document, EURAMET.L-K1.2011, is parallel to the CIPM key comparison CCL-K1.2011 which is piloted by CENAM and NRC. Key Comparison EURAMET.L-K1 was instigated following a decision at the 2010 meeting of the EURAMET Length contact persons held at SP Technical Research Institute of Sweden.

The sets of gauge blocks used in both the CCL and EURAMET key comparisons have almost the same composition, i.e. steel and ceramic gauges ranging from 0,5 mm to 500 mm in length.

BEV (AT) acts as pilot laboratory for EURAMET.L-K1 with substantial help by PTB (DE) for the stability measurements on long gauge blocks. It should be noted that PTB is not a participant of this very comparison (instead it will take part in the corresponding COOMET.L-K1 loop)

The procedures outlined in this document cover the technical procedure to be followed during measurement of the gauge blocks. A goal of the CCL 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) [1]. 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 of this document. Due to the large number of participants, it is very important that participating NMIs perform their measurements during assigned dates. Participants should keep in mind that the allocated time period is not only for measurements, but transportation and customs clearance as well.

2. Organization

The comparison will be coordinated by the BEV (AT) as the pilot laboratory with substantial help by PTB (DE) for the long gauge blocks. Due to the large number of participant the comparison will be performed in two concurrent loops. Laboratories outside the EU (with any kind of customs barriers) are pooled in loop 1. (METAS also in loop 2 for linking reasons)

2.1 Participants

The list of participants was prepared by the pilot laboratory after soliciting participation from any interested EURAMET NMIs. All participants must be able to demonstrate traceability to the realization of the metre. Moreover they must be capable to calibrate the gauge blocks using an interferometric (or other primary) technique. Calibration by comparison to standard gauge blocks of similar nominal size is not a topic of this project.

By their declared intention to participate in this key comparison, the laboratories accept the general instructions and the technical protocols written down in this document and commit themselves to follow the procedures strictly. Once the protocol and list of participants has been agreed, no change to the protocol or list of participants may be made without prior agreement of all participants.

Table 1. Participants, contact details, assignment to loop number. NMIs marked in red are the linking laboratories to CCL-K1.2011

Country	NMI	Contact person	Postal address	Telephone FAX	E-mail	short gb	long gb	loop #
AT	**BEV**	Michael Matus	Arltgasse 35, A-1160 Wien, Austria	++43 1 21110 6540 ++43 1 21110 6000	michael.matus@bev.gv.at	X	X	1 2
BE	**SMD**	Hugo Piree	Boulevard du Roi Albert II 16, BE-1000 Brussels	++32 2 277 7610 ++32 2 277 5405	hugo.piree@economie.fgov.be	X	X	2
BG	**BIM**	Veselin Gavalyugov Denita Tamakyarska	52B, G.M. Dimitrov blvd. BG-1040 Sofia	++359 2 873 52 68 ++359 2 873 52 85	v.gavalyugov@bim.government.bg d.tamakjarska@bim.government.bg		X	2
CH	**METAS**	Rudolf Thalmann	Lindenweg 50, CH-3003, Bern-Wabern, Switzerland	++41 31 32 33 385 ++41 31 32 33 210	rudolf.thalmann@metas.ch	X	X	1 2
CZ	**CMI**	Petr Balling	V Botanice 4 CZ-15072 Prague 5	++420 257 288 326 ++420 257 328 077	pballing@cmi.cz	X	X	2
DK	**DANIAmet-DFM**	Joergen Garnaes	Matematiktorvet 307 DK-2800 Kongens Lyngby	++45 45 93 1144 ++45 45 93 1137	jg@dfm.dtu.dk	X		1
EG	**NIS**	Mohamed EL Bahrawi	Tersa Street El Haram, P.O. Box: 136 EG-12211 Giza	++201223191140 ++202 3867451	mbahrawi@hotmail.com	X		1
ES	**CEM**	Emilio Prieto	C/del Alfar 2 ES-28760 Tres Cantos (Madrid)	++34 91 807 47 16 ++34 91 807 48 07	eprieto@cem.mityc.es	X	X	2
FI	**MIKES**	Antti Lassila	Tekniikantie 1, FI-02151, Espoo, P.O. Box 9, Finland	++358 10 6054 000 ++358 10 6054 499	antti.lassila@mikes.fi	X	X	1 2
FR	**LNE**	Georges Vailleau	rue Gaston Boissier 1 FR-75724 Paris cedex 15	++33 1 40 43 37 77 ++33 1 40 43 37 37	georges.vailleau@lne.fr	X	X	2
GB	**NPL**	Andrew Lewis	Hampton Road GB-TW11 0LW Teddington, Middlesex	++44 20 8943 6074 ++44 20 8614 0533	andrew.lewis@npl.co.uk	X	X	2
GR	**EIM**	Christos Bandis	Industrial Area of Thessaloniki, Block 45 GR-57022 Sindos, Thessaloniki	++30 310 569 999 ++30 310 569 996	bandis@eim.gr	X		1
HR	**HMI/FSB-LPMD**	Vedran Mudronja	Ivana Lučića 5 HR-1000 Zagreb	++385 1 616 8327 ++385 1 616 8599	vedran.mudronja@fsb.hr	X		1
HU	**MKEH**	Edit Bánréti	Németvölgyi út 37-39 HU-1124 Budapest XII.	++36 1 458 59 97 ++36 1 458 59 27	banretie@mkeh.hu	X		1
IT	**INRIM**	Alessandro Balsamo Paola Pedone	Strada delle Cacce 91, IT-10135 Torino, Italy	++39 011 3919 970 ++39 011 3919 959	a.balsamo@inrim.it p.pedone@inrim.it	X	X	2
NL	**VSL**	Rob H. Bergmans	Thijsseweg 11 NL-2629 JA Delft	++31 15 269 16 41 ++31 15 261 29 71	rbergmans@vsl.nl	X	X	2
NO	**JV**	Helge Karlsson	Fetveien 99 NO-2007 Kjeller	++47 64 84 84 84 ++47 64 84 84 85	hk@justervesenet.no	X		1
PL	**GUM**	Zbigniew Ramotowski	ul. Elektoralna 2 Zip/City: PL-00 950 Warszawa	++48 22 581 9543 ++48 22 620 8378	length@gum.gov.pl	X	X	2
PT	**IPQ**	Fernanda Saraiva	Rua António Gião 2 PT-2829-513 Caparica	++351 21 294 81 60 ++351 21 264 81 88	fsaraiva@mail.ipq.pt	X		1
RO	**INM**	Alexandru Duta	Sector 4 Sos. Vitan-Bârzesti 11 RO-042122 Bucuresti	++40 21 334 5060 ++40 21 335 533	alexandru.duta@inm.ro	X		2
RS	**DMDM**	Slobodan Zelenika	Mike Alasa 14 RS-11 000 Beograd	++381 11 20 24 421 ++381 11 21 81 668	zelenika@dmdm.rs	X		1
SE	**SP**	Sten Bergstrand	P.O. Box 857 Zip/City: SE-50115 Borås	++46 10 516 57 73 ++46 10 516 56 20	sten.bergstrand@sp.se	X	X	2
SK	**SMU**	Roman Fíra	Karloveská 63 SK-842 55 Bratislava	++421 2 602 94 232 ++421 2 654 29 592	fira@smu.gov.sk	X		1
TR	**UME**	Damla Sendogdu	TÜBİTAK Barış Mah. Dr.Zeki Acar Cad. No:1 TR-41470 Gebze, Kocaeli	++90 262 679 50 00 / 3552/3505 ++90 262 679 50 01	damla.sendogdu@tubitak.gov.tr	X	X	1
DE	**PTB**	Peter Franke	Bundesalle 100, DE-38116 Braunschweig, Germany	+49 531 592 5430 +49 531 592 4305	peter.franke@ptb.de		X	0

2.2 Time 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 six weeks that include customs clearance, calibration and transportation to the following participant. With its confirmation to participate, each 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. If a laboratory has technical problems to perform the measurements or customs clearance takes too long, the laboratory has to contact the pilot laboratory as soon as possible and, according to whatever it decides, it might eventually be obliged to send the standards directly to the next participant before completing the measurements or even without doing any measurements.

All results are to be communicated directly to the pilot laboratory as soon as possible and certainly within six weeks of the completion of the measurements by a laboratory. The comparison will be carried out with at least one pilot intermediate measurement check during the circulation. The settled dates for both loops are indicated in table 2.

Table 2. Time schedule. Entries marked in red are allocated for the stability measurements. Data from the green entries are used for the intra-comparison linking. Shaded entries are non-EU participants and need special attention due to customs barriers. All periods start on a Monday, respectively.

Period	(starting date)	Loop 1	Loop 2
1	02. Jan. 2012	BEV (PTB)	BEV (PTB)
2	13. Feb. 2012	MKEH	SP
3	26. Mar. 2012	SMU	MIKES
4	07. May 2012	BEV	VSL
5	18. Jun. 2012	EIM	SMD
6	30. Jul. 2012	DANIAmet-DFM	LNE
7	10. Sep. 2012	BEV (PTB)	BEV (PTB)
8	22. Oct. 2012	BEV	METAS
9	03. Dec. 2012	METAS	NPL
10	14. Jan. 2013	HMI/FSB-LPMD	CEM
11	25. Feb. 2013	DMDM	INRIM
12	08. Apr. 2013	UME	CMI
13	20. May 2013	JV	GUM
14	01. Jul. 2013	BEV	INM
15	12. Aug. 2013	MIKES	BEV / SMD
16	23. Sep. 2013	BEV (PTB)	BEV (PTB)
17	04. Nov. 2013	NIS	BIM
18	16. Dec. 2013	BEV	IPQ
19	27. Jan. 2014	BEV (PTB)	BEV (PTB)

2.3 Transportation

Shipping and insurance costs to the following participating laboratory is the responsibility of each participant. Two nominally equal plastic cases, each containing 3 long gauge blocks and a wooden case for the short gauge blocks, respectively, are used for the transportation of the artefacts. (Figure 1.)

The organization costs will be covered by the pilot laboratory, which include the standards themselves, the cases and packaging, and the shipping costs for the non EU laboratories only. The pilot laboratory has no insurance for any loss or damage of the standards during the circulation.

Figure 1 – Transporting cases

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. Please cover them with this product before packing them for transportation or when stocked for more than three days. If, at any point during circulation, the package is damaged, it shall be repaired by the laboratory before shipping it again. In order to avoid problems with missing ATA carnet or other costumes troubles the participants are grouped in two categories.

Instructions for EU members
This refers to the not shaded entries of table 2.

Each participating laboratory shall cover the costs of shipping and transport insurance against loss or damage. The package should be shipped with a reliable parcel service of its choice. Once the measurements have been completed, please inform the pilot laboratory and the following participant when the package leaves your installations indicating all pertinent information.

Instructions for NON-EU members
This refers to the 6 shaded entries of table 2, i.e. METAS, HMI/FSB, JV, UME, DMDM, and NIS

The pilot laboratory has organized an international forwarding agent who takes care of all custom and transportation formalities. Once the measurements have been completed, inform the pilot laboratory in due time so that it can give order to the forwarding agent. Please take care to leave some time for the actual transportation, the Friday before the start of the next period is the last chance for pickup. The pilot needs at least one day to contact the forwarding agent. The costs for this service will be covered by the pilot.

3. Description of the standards

Each of the two packages contains 19 gauge blocks. The gauge blocks are of rectangular cross section and comply with the calibration grade K of the standard [2]. 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 by the manufactures and should be used as such. Following a decision by the WGDM a pre-determination of this important artefact parameter is not to be communicated to the participants.

Table 3. Gauge blocks for the two loops.

Class	Nominal length / mm	α / 10^{-6} K^{-1}	Manufacturer	Identification number Loop 1	Identification number Loop 2
short, steel	0,5	11,9	KOBA	88286	88287
	1,15	11,9	KOBA	87050	87051
	3	11,9	KOBA	88286	87646**
	5	11,9	KOBA	88286	88287
	7	11,9	KOBA	88286	88287
	23,5	11,9	KOBA	88286	88287
	80	11,9	KOBA	88286	88287
	100	11,9	KOBA	88286	88287
short, ceramic	0,5	9,3	KOBA	10485	10550
	1,15	9,3	KOBA	10314	10329
	3	9,3	KOBA	10942	10932
	5	9,3	KOBA	10978	10982
	7	9,3	KOBA	10745	10710
	23,5	9,3	KOBA	10060	10071
	80	9,3	KOBA	10340	10315
	100	9,3	KOBA	10600	10399
long, steel	150	11,6*	Hoffmann	110146	110147
	300	11,6*	Hoffmann	110146	110147
	500	11,5*	Hoffmann	110146	110147

* The CTE of these 6 blocks were determined by PTB with low uncertainty. In the table the values are intentionally stated inaccurate. The participants should use them like manufacturers data.

** was No.: 88287 for the first participant only. Replaced after accident.

The rationale behind the selection of the gauge blocks is as follows. Timely availability, option to the stack method for optical phase change correction (see section 4.6), possibility to apply a link to CCL-K1 (see section 6.5), same nominal lengths for steel vs. ceramic gauge blocks to reduce uncertainty of stability measurements by mechanical comparison (relevant for pilot only, see section 6.2).

4. Measurement instructions

The gauge blocks shall be measured based on the standard procedure that the laboratory regularly uses for this calibration service for its customers. The “A” surface is the marked measuring face for gauge blocks with nominal length < 6 mm and the right hand measuring face for gauge blocks with a nominal length ≥ 6 mm, respectively (see Figure 2).

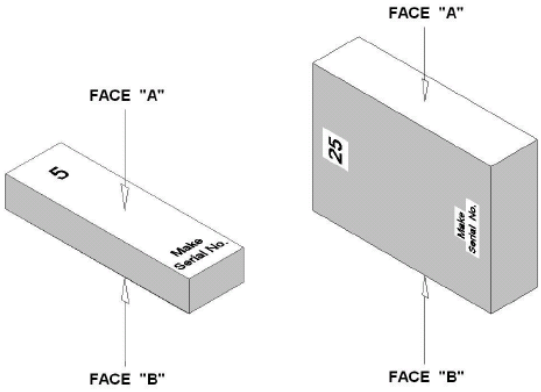


Figure 2 – Nomenclature of faces

4.1 Handling of artefacts

The gauge blocks should only be handled by authorized persons and stored in such a way as to prevent damage. Before making the measurements, the gauge blocks need to be checked to verify that their measuring surfaces are not damaged and do not present severe scratches and/or rust that may affect the measurement result. The condition of the blocks before measurement should be registered in the form provided in appendix B and appendix C. Laboratories should attempt to measure all gauge blocks unless doing so would damage their equipment. If a gauge block will not wring readily, the participant shall inform the pilot about this problem, stating the respective gauge block and face. No participant shall try to re-finish measuring faces by burring, lapping, stoning, or whatsoever. The measurement of the face concerned or the complete gauge block shall be omitted.

No other measurements are to be attempted by the participants and the gauge blocks should not be used for any purpose other than described in this document. The gauge blocks may not be given to any party other than the participants in the comparison.

The gauge blocks should be examined before despatch and any change in condition during the measurement at each laboratory should be communicated to the pilot laboratory. After the measurements, the gauge blocks must be cleaned and greased. Ensure that the content of the package is complete before shipment. Always use the original packaging.

4.2 Traceability

Length measurements should be traceable to the latest realisation of the metre as set out in the current "*Mise en Pratique*". Temperature measurements should be made using the International Temperature Scale of 1990 (ITS-90).

4.3 The Measurand

The measurand to be reported is the deviation e_c of the central length l_c from the nominal length l_n of a gauge block. In this project the arithmetic mean of the two values for wringing on both faces is considered as representative for e_c (see equation (1), the superscripts label the face wrung to the platen). In cases where only one face could be wrung the corresponding value should be reported as the result.

$$e_c = \left(e_c^A + e_c^B\right)/2 \quad \text{with} \quad e_c^A = l_c^A - l_n \quad \text{and} \quad e_c^B = l_c^B - l_n \tag{1}$$

As an auxiliary measurand the difference of the found deviations d_c when the block is wrung to face A and face B, respectively, should be reported according to equation (2). Care has to be taken to use the correct sign.

$$d_c = e_c^A - e_c^B = l_c^A - l_c^B \tag{2}$$

4.4 Measurement uncertainty

The uncertainty of measurement shall be estimated according to the ISO Guide to the Expression of Uncertainty in Measurement [3]. Although comparability is sacrificed by not giving an explicit model equation, the participating laboratories are encouraged to use their usual model for the uncertainty calculation. Examples for model equations might be found in [4, 5, 6].

All measurement uncertainties shall be stated as standard uncertainties. If appropriate the corresponding effective degree of freedom might be stated by the participants. If none is given, ∞ is assumed. (Note: for principal reasons the concept of degree of freedom is undefined in presence of correlations (6.3) it will not be taken into account for the analysis of results.) For efficient evaluation and subsequent assessment of CMC claims an uncertainty statement in the functional form (3) is preferred.

$$u(e_c) = Q[a, b \cdot l_n] = \sqrt{a^2 + (b \cdot l_n)^2} \quad (3)$$

4.5 Reference condition

Measurement results should be reported for the reference conditions as set down in the standard [2]. Specifically the reference temperature of 20 °C, standard pressure of 101 325 Pa and the orientation are of importance. For corrections the linear thermal expansion coefficient provided in this document (table 3) should be used. Additional corrections may be applied according to the specific procedure of each laboratory. One of them is discussed in the following subsection.

4.6 Optical phase change and roughness correction

The position of the plane where light is reflected on a surface is depending mainly on the material and surface finish. As the free measuring face of the gauge block under measurement and the platen where it is wrung are in general different in both characteristics, this difference varies and a correction has to be applied. It shall be estimated or determined by each laboratory according to its calibration procedure as it usually does it for its customers.

Methods usually applied to determine this correction are the stack method, the total integrating sphere technique, the coupled interferometer method, etc. Participants should state their technique in appendix E.

5. Reporting of results

As soon as possible after measurements have been made, the results should be communicated to the pilot laboratory and at the latest within six weeks.

The measurement report forms in appendix D of this document will be sent by e-mail (Word document) to all participating laboratories. It would be appreciated if the report forms (in particular the results sheet) could be completed by computer and sent back electronically to the pilot. **In any case, the signed report must also be sent in paper form by mail.** In case of any differences, the paper forms are considered to be the definitive version.

Following receipt of all measurement reports from the participating laboratories, the pilot laboratory will analyse the results and prepare a first draft report on the comparison. This will be circulated to the participants for comments, additions and corrections. The procedure outlined in the document [11] will be followed.

6. Analysis of Results

The check for consistency of the results with their associated uncertainties will be made by calculating the E_n value for each laboratory and each gauge block measured with respect to the key comparison reference value as defined in the next section.

6.1 Key comparison reference value (KCRV)

Essentially the key comparison reference value (KCRV) is calculated on a gauge-per-gauge basis as the weighted mean of the participant results. The statistical consistency will be investigated the techniques outlined in [6, 10].

The simple picture is however a little more complicated due to: artefact instability, correlations between institutes, and the necessity for linking the two loops and to CCL-K1, respectively.

6.2 Artefact instability

Steel gauge blocks occasionally show a growing or a shrinkage the rate of which is approximately linear with time. Since the artefacts used here are of unknown history, the instability of the blocks must be determined in course of the comparison. For this check the measurements of the pilot laboratories are used exclusively, not that of the other participants. Using these data a linear regression line is fitted and the slope together with its uncertainty is determined (per gauge block).

Three cases can be foreseen:

a) The linear regression line is an acceptable drift model and the absolute drift is smaller than its uncertainty. The gauge block is considered stable and no modification to the standard evaluation procedure will be applied. In fact the results of the pilot's stability measurements will not influence the numerical results in any way.
b) The linear regression line is an acceptable drift model and the absolute drift is larger than its uncertainty, i.e. there is a significant drift for the gauge block. In this case an analysis similar to [7] will be followed. The pilot influences the KCRV by the slope of the drift only, not by the measured absolute lengths.
c) The data are not compatible at all with a linear drift, regarding the uncertainties of the pilot's measurements. In this case the artefact is unpredictable unstable or the pilot has problems with its measurements. TC-L has to determine the further approach. (This should not happen.)

6.3 Correlation between laboratories

Since the topic of this project is the comparisons of primary measurements, correlations between the results of different NMIs are unlikely. A possible exception is the common use of the recommended thermal expansion coefficients (from table 3). A correlation will become relevant only when the gauge blocks are calibrated far away from 20 °C which should not be the case. Thus correlations are normally not considered in the analysis of this comparison.

However if a significant drift exist, correlations between institutes are introduced by the analysis proposed in section 6.2. This correlation will be accounted for in the analysis outlined in [7].

6.4 Linking the two loops

The linking of the two loops within this comparison is performed using the measurements of three linking labs (BEV, METAS, MIKES; green entries in table 2) according to the technique outlined in [8, 9]. Most probable only a selected set of gauge blocks will be used for linking, depending on stability and the nominal lengths needed for linking to the results of CCL-K1.2011.

6.5 Linking to CCL-K1.2011

For the KCRV (linked within this comparison according to section 6.4) the linking to CCL-K1.2011 will be performed according to the technique outlined in [10].

The linking will be performed as follows: the analysis proposed by CCL TG-L is used to check that the two comparisons to be linked are equivalent, with respect to the performance of the linking laboratories. If the comparisons are shown to be equivalent, the data from the later comparison are plotted on the graph of the earlier comparison, with a linking offset determined such that the mean value of the linking laboratories is preserved across the two comparisons. This plots will be presented on a per gauge block basis for as many blocks as feasible.

The respective linking labs (INRIM, METAS, MIKES) are marked in red in table 1.

References

[1] CIPM 1999 Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes *BIPM*.

[2] ISO 3650:1998(E), *Geometrical Product Specification (GPS) – Length Standards – Gauge Blocks*, International Organization for Standardization, Geneva, Switzerland.

[3] JCGM 100:2008 Guide to the Expression of Uncertainty in Measurement *BIPM*

[4] Decker J E, Pekelsky J R 1997 Uncertainty evaluation for the measurement of gauge blocks by optical interferometry *Metrologia* **34** 479-493

[5] Viliesid M 2011 Technical Protocol document, key comparison CCL-K1

[6] Lewis A 2006 Final Report on EUROMET Key Comparison EUROMET.L-K2: Calibration of long gauge blocks *Metrologia* **43** 04003

[7] Nien F Z et al. 2004 Statistical analysis of key comparisons with linear trends *Metrologia* **41** 231

[8] Krystek M, Bosse H 2010 A Bayesian approach to the linking of key comparisons *to be published*

[9] Acko B 2012 Final Report on EURAMET Key Comparison EURAMET.L-K7: Calibration of line scales *to be published*

[10] Lewis A 2012 Guide to preparation of Key Comparison Reports in Dimensional Metrology *CCL/WG-MRA/GD-2*

[11] Lewis A 2012 Running of MRA comparisons in length metrology and monitoring their impact on CMCs *CCL/WG-MRA/GD-1*

Appendix A – Reception of Standards

To:	Michael Matus, c/o Bundesamt für Eich- und Vermessungswesen (BEV) Arltgasse 35, A-1160 Wien, Austria Fax: ++43 1 21110 6000 e-mail: michael.matus@bev.gv.at
From:	NMI: …… Name: …… Signature: …… Date: ……

We confirm having received the gauge blocks for the EURAMET.L-K1:2011 comparison of Gauge Blocks by Interferometry on the date given above.

After a visual inspection:

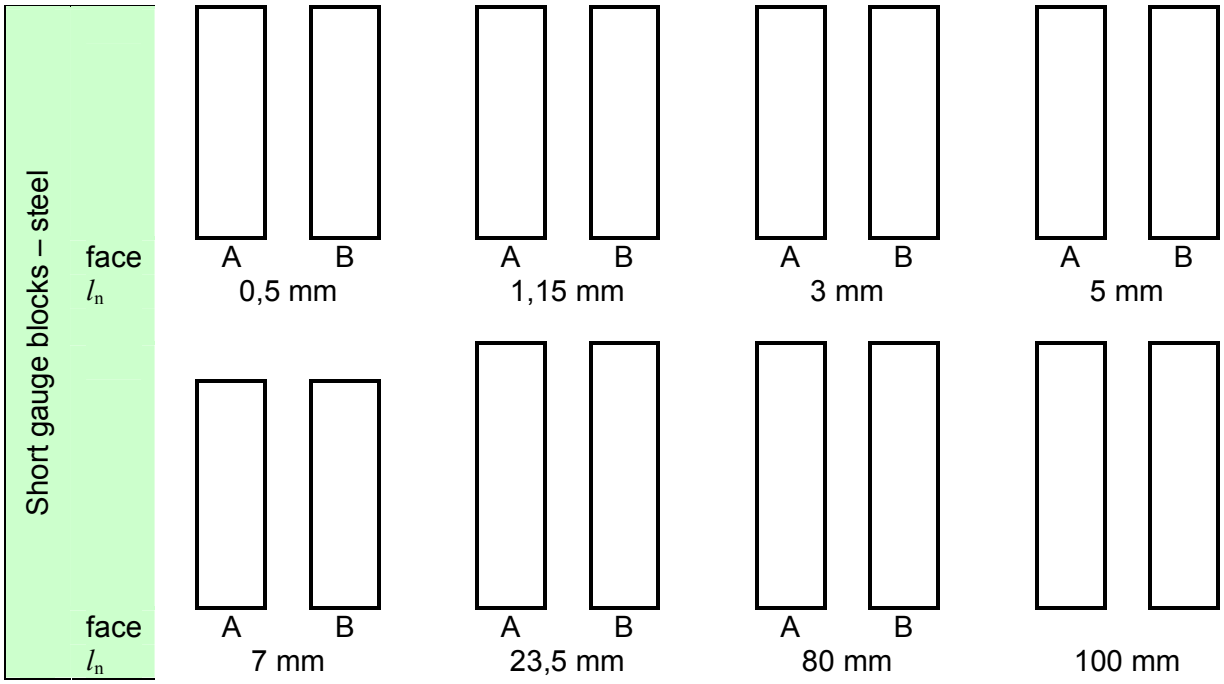
- ☐ There are no apparent damages; their precise state will be reported in the form provided in Annex B/C once inspected in the laboratory along with the measurement results.
- ☐ We have detected severe damages putting the measurement results at risk. Please indicate the damages, specifying every detail and, if possible, include photos. If it is necessary use additional sheets to report it.

Appendix B – Conditions of Measuring Faces (short GB)

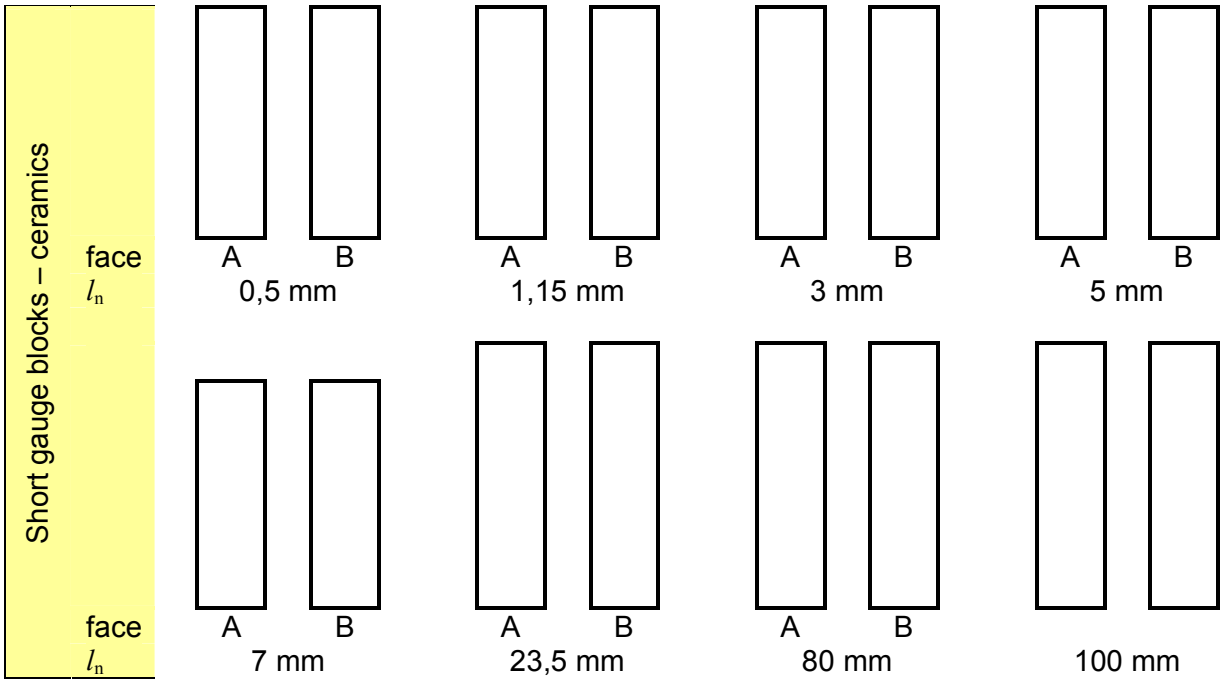
To:	Michael Matus, c/o Bundesamt für Eich- und Vermessungswesen (BEV) Arltgasse 35, A-1160 Wien, Austria Fax: ++43 1 21110 6000 e-mail: michael.matus@bev.gv.at
From:	NMI: …… Name: …… Signature: …… Date: ……

After detailed inspection of the measuring faces of the gauge blocks these are the results. Please mark significant surface faults (scratches, indentations, corrosion, etc.)

Short gauge blocks – steel



Short gauge blocks – ceramics

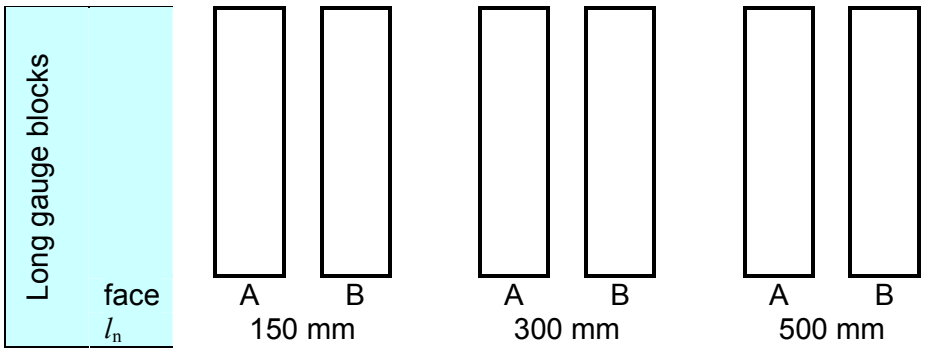


Appendix C – Conditions of Measuring Faces (long GB)

To:	Michael Matus, c/o Bundesamt für Eich- und Vermessungswesen (BEV) Arltgasse 35, A-1160 Wien, Austria Fax: ++43 1 21110 6000 e-mail: michael.matus@bev.gv.at
From:	NMI: …… Name: …… Signature: …… Date: ……

This sheet has to be returned only by NMIs actually calibrating the long gauge blocks. Laboratories participating in the short gauge block part exclusively should not remove the long blocks at all!

After detailed inspection of the measuring faces of the gauge blocks these are the results. Please mark significant surface faults (scratches, indentations, corrosion, etc.)



Appendix D – Results Report Form

To:	Michael Matus, c/o Bundesamt für Eich- und Vermessungswesen (BEV) Arltgasse 35, A-1160 Wien, Austria Fax: ++43 1 21110 6000 e-mail: michael.matus@bev.gv.at
From:	NMI: …… Name: …… Signature: …… Date: ……

Short gauge blocks, steel							
l_n / mm	Ident. number	e_c / nm	$u(e_c)$ / nm	ν_{eff}	d_c / nm	$u(d_c)$ / nm	ν_{eff}
0,5							
1,15							
3							
5							
7							
23,5							
80							
100							

Short gauge blocks, ceramic							
l_n / mm	Ident. number	e_c / nm	$u(e_c)$ / nm	ν_{eff}	d_c / nm	$u(d_c)$ / nm	ν_{eff}
0,5							
1,15							
3							
5							
7							
23,5							
80							
100							

Long gauge blocks, steel							
l_n / mm	Ident. number	e_c / nm	$u(e_c)$ / nm	ν_{eff}	d_c / nm	$u(d_c)$ / nm	ν_{eff}
150							
300							
500							

For the (non mandatory) length depended expressions of uncertainty see overleaf.

Functional form of standard uncertainty

$$u(e_c) = Q[a, b \cdot l_n] = \sqrt{a^2 + (b \cdot l_n)^2}$$

Gauge block set	a / nm	b / 1	Comment
Short, steel			
Short, ceramic			
Long, steel			

The above given values should be valid for nominal length between 0 mm and 100 mm for the short blocks and 100 mm and 500 mm for the long blocks, respectively. In any case the uncertainty values given in the preceding tables will be used for the analysis of the results, so the statement is not mandatory.

Appendix E – Description of the measurement instrument

To:	Michael Matus, c/o Bundesamt für Eich- und Vermessungswesen (BEV) Arltgasse 35, A-1160 Wien, Austria Fax: ++43 1 21110 6000 e-mail: michael.matus@bev.gv.at
From:	NMI: …… Name: …… Signature: …… Date: ……

Make and type of instrument(s).....

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Light sources / wavelengths used or traceability path: .....

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Description of measuring technique (including any corrections such as phase correction & platen material, vertical to horizontal corrections etc): .....

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Range of gauge block temperature during measurements & description of temperature measurement method: .....

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(use additional pages as needed)