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Federal Institute of Metrology METAS

EURAMET Key Comparison EURAMET.L-K8.2013
Calibration of surface roughness standards
EURAMET project #1245

Technical protocol

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Wabern, January 2013

Contents

1 Document control

Version Draft 0.1	Issued on 15 November 2012.
Version Draft 0.2	Issued in January 2013
Final version 1.0	Issued in March 2013

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.

At its meeting in October 2012, the EURAMET Technical Committee for length, EURAMET-TCL, decided upon a key comparison on the calibration of surface roughness standards, named EURAMET.L-K8.2013, with METAS as the pilot laboratory. The comparison was registered in January 2013, artefact circulation is supposed to start in early 2013 and finish in mid 2014.

The procedures outlined in this document cover the technical procedure to be followed during the measurements. 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). 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. 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.

3 Organization

3.1 Participants

Give a concise list of the participants.

Table 1. List of participant laboratories and their contacts.

Laboratory Code	Contact person, Laboratory	Phone, Fax, email
METAS (Pilot)	Ruedi Thalmann Federal Institute of Metrology METAS Lindenweg 50 CH-3003-Bern-Wabern Switzerland	Tel. +41 58 387 03 85 Fax +44 58 387 02 10 e-mail: rudolf.thalmann@metas.ch
LNE	Georges Vailleau LNE Laboratoire national de métrologie et d'essais 1, rue Gaston Boissier F-75015 Paris France	Tel. +33 1 40 43 3777 Fax +33 1 40 43 3737 e-mail: georges.vailleau@lne.fr
INRIM	Gian Bartolo Picotto Istituto Nazionale di Ricerca Metrologica Strade delle Cacce, 91, 10135 Torino Italy	Tel : 39 11 3919 969 or 973 Fax : 39 11 3919 959 e-mail : g.picotto@inrim.it
BEV	Michael Matus Bundesamt für Eich- und Vermessungswesen BEV Arltgasse 35 A-1160 Wien Austria	Tel. +43 1 21110 6540 Fax +43 1 21110 6000 e-mail: michael.matus@bev.gv.at
CEM	Laura Carcedo Head of the Surface Quality Laboratory Length Area CENTRO ESPAÑOL DE METROLOGÍA Alfar, 2 - Tres Cantos 28760 Madrid Spain	Tel. +34 918074716 Fax +34 918074807 e-mail: lcarcedo@cem.minetur.es
MIKES	Antti Lassila Mittatekniikan keskus - Centre for Metrology and Accreditation (MIKES) P.O. box 9 (Tekniikantie 1) FIN-02151 Espoo Finland	Tel: +358 2950 54413 GSM: +358 40 7678584 Fax: +358 2950 54 499 e-mail: Antti.Lassila@mikes.fi
UME	Okhan Ganioglu TÜBİTAK UME Ulusal Metroloji Enstitüsü TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze / Kocaeli Turkey	Tel : +90 262 679 50 00 (ext. 5300) Fax : +90 262 679 50 01 e-mail : okhan.ganioglu@tubitak.gov.tr

DTU-CGM	Leonardo De Chiffre DTU Mekanik – CGM Produktionstorvet 427A DK-2800 Kgs. Lyngby Denmark	Tel. +45 45 25 47 60 Fax +45 45 93 01 90 e-mail: ldch@mek.dtu.dk
GUM	Zbigniew Ramotowski Central Office of Measures (GUM) Director of Length & Angle Department ul. Elektoralna 2 00-139 Warszawa Poland	Tel.: +48 22 581 95 43 Fax: +48 22 620 83 78 e-mail: length@gum.gov.pl
IPQ	Fernanda Saraiva Instituto Portugês da Qualidade Rua António Gião, 2 2829-513 CAPARICA Portugal	Tel: + 351 21 2948160 Fax: + 351 21 2848188 e-mail: fsaraiva@ipq.pt
SP	Sten Bergstrand SP Technical Research Institute of Sweden Measurement Technology Box 857 SE-501 15 Borås Sweden	Tel. +46 10 516 57 73 Fax +46 10 516 56 20 e-mail: sten.bergstrand@sp.se
DMDM	Zelenika Slobodan Directorate of Measures and Precious Metals Mike Alasa 14 11000 Belgrade Serbia	Tel : +381112024421 Fax : +381112181668 e-mail: zelenika@dmdm.rs
NIMT	Anusorn Tonmueanwai NIMT Thailand	Tel : +662 5775100 ext 1202 Fax : +662 5775088 e-mail: anusorn@nimt.or.th
CMS/ITRI	Chin-Lung Tsai (Walter Tsai) CMS/ITRI Bldg. 16, No. 321, Sec. 2, Kuang Fu Rd. Hsinchu city 30011 Taiwan (R.O.C.)	Tel: +886 3 5743764 Fax: +886 3 5726445 e-mail: Walter_Tsai@itri.org.tw
NMC/ A*Star	Tan Siew Leng NMC/A*Star Singapore	Tel : Fax : e-mail: tan_siew_leng@nmc.a-star.edu.sg
NMISA	Oelof Kruger Bld 5 CSIR campus Meiring Naude road, Brumeria Pretoria South Africa	Tel : + 27 12 841 4340 Fax : + 27 12 841 4458 e-mail: oakruger@nmisa.org
INMETRO	Marcos Motta de Souza Dimensional Metrology Laboratory INMETRO - National Institute of Metrology Quality and Technology Av. N.Sra. das Graças, 50 CEP:25250020 Xérem, Duque de Caxias, RJ. Brazil	Tel. +55 21 2679 9726 Fax +55 21 2679 9597 e-mail: mmsouza@inmetro.gov.br

3.2 Schedule

The participating laboratories were asked to specify a preferred timetable slot for their own measurements of the surface measurement standards – 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, 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.

Table 2. Schedule of the comparison.

RMO	Laboratory	Starting date of measurement
EURAMET	METAS	Mar 2013
	DTU-CGM	Apr 2013
	MIKES	May 2013
	IPQ	Jun 2013
	BEV	July 2013
	SP	Aug 2013
	UME	Sept 2013
	LNE	Oct 2013
	CEM	Nov 2013
	INRIM	Dec 2013
	DMDM	Jan 2014
	GUM	Feb 2014
	METAS	Mar 2014(stability check)
APMP	NIMT	Apr 2014
	NMC/A*Star	May 2014
	CMS/ITRI	Jun 2014
AFRIMETS	NMISA	Jul 2014
SIM	INMETRO	Aug 2014
EURAMET	METAS	Sept 2014 (stability check)

3.3 Reception, transportation, insurance, costs

A plastic case (40 cm x 32 cm x 17 cm) containing 4 wooden boxes with the artefacts and the technical protocol is used for transportation (Figure 1). The plastic case is shipped in a larger cardboard box, which might be replaced by the participants if damaged. Upon reception of the package, each 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 of Appendix A.

Figure 1 – Transporting case

The organization costs will be covered by the pilot laboratory, which include the standards themselves, the cases and packaging, and the shipping costs to the next laboratory. Therefore each participating laboratory shall cover the costs of shipping and transport insurance against loss or damage. The pilot laboratory has no insurance for any loss or damage of the standards during the circulation.

Once the measurements have been completed, the package shall be sent to the following participant. 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. If, at any point during circulation, the package is damaged, it shall be repaired by the laboratory before shipping it again.

For shipment outside the EU the package is accompanied by an ATA carnet. Outside EU the carnet shall always be shipped with the package, never inside the box, but apart. **Please be certain, that when receiving the package, you also receive the carnet!** For shipment inside the EU the ATA carnet may be shipped inside the box.

5 Artefacts

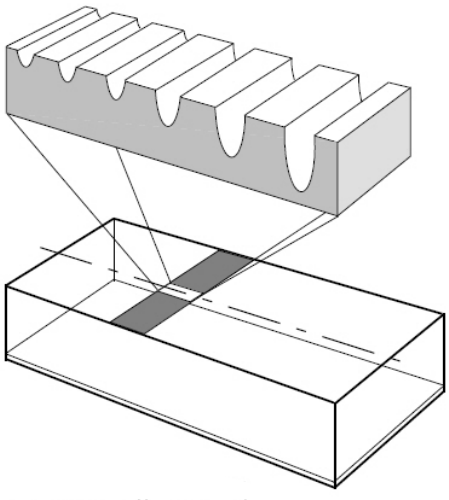
The package contains four standards in their leather package and enveloped in a lint free tissue: one type A2, two type C1 and one type D1 according to ISO 5436-1. The standards are from different manufacturers and different materials.

5.1 Type A2 standard

Depth measurement standard, KNT 2060/01, S/N 0589606
Manufacturer: Halle, material: glass
6 grooves with rounded bottoms,
nominal values *d* 0.33 µm to 8.93 µm

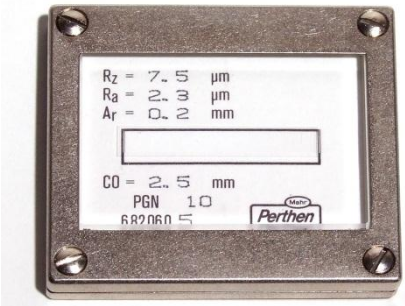
Technical specification

Groove geometry



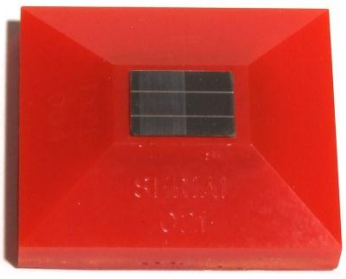
5.2 Type C1 standard

Spacing measurement standard, PGN 10, no 682060 5
Manufacturer: Perthen, material: glass
sine wave profile,
nominal values *Ra* 2.3 µm, *RSm* 200 µm

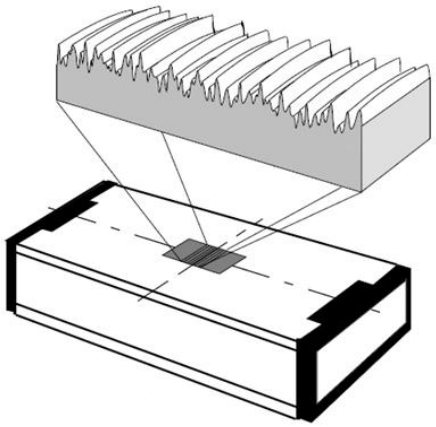


5.3 Type D1 standard

Roughness measurement standard, type004, S/N 021
Manufacturer: Rubert, material: electroformed metal,
unidirectional irregular profile,
nominal values *Ra* 0.15 µm



5.4 Type D1 standard



Roughness measurement standard, KNT 2070/03, S/N 0986
Manufacturer: Halle, material: hard nickel plate
unidirectional irregular profile,
nominal values *Ra* 0.06 µm

Description

Technical specification

5.5 Additional type C1 standard

Spacing measurement standard, NIST SRM 2072, S/N 1015
Manufacturer: NIST, material: steel
sine wave profile,
nominal values *Ra* 1 µm, *RSm* 100 µm

5.6 Type F1 Reference data (softgauge)

Two softgauges in 7-bit ASCII character code (*.smd format) according to ISO 5436-2 are included in a memory stick to investigate software algorithms independently of hardware variation:

METAS_Aperiodic.smd: Aperiodic profile
METAS_Periodic.smd: Periodic profile

The two data files correspond to primary profiles, i.e. after removal of form but before λs filtering.
The *.smd format may be easily opened with a simple text editor (e.g. Notepad). Laboratories not able to read smd-files with their evaluation software may edit the file header without changing the data in order to make the file compatible with their software.
The evaluation of the softgauges is only mandatory for the participants having a corresponding CMC.

6 Measuring instructions

6.1 Handling the artefact

The standards need to be handled with care and stored in a clean environment. Please do not clean other than eventually removing dust. In case a laboratory decides that cleaning is necessary, please document the status of the surface before and after cleaning and describe the cleaning procedure you have applied.

6.2 Measurands

The following parameters are to be determined:

Artefact	**Parameters**	**Relevant standards**
Type A2 KNT 2060/01	*d, Pt*	ISO 5436-1 ISO 4287
Type C1 PGN 10	*Ra, Rq, Rz, Rt, RSm*	ISO 5436-1 ISO 4287
Type D1 S/N 021	*Ra, Rq, Rz, Rt*	ISO 5436-1 ISO 4287
Type D1 KNT 2070/03	*Ra, Rq, Rz, Rt*	ISO 5436-1 ISO 4287
Type C1 SRM 2072	*Ra, Rq, Rz, Rt, RSm*	ISO 5436-1 ISO 4287
Type F1	*Ra, Rq, Rz, Rt, Rsk, (RSm)*	ISO 5436-2 ISO 4287

Note: For each parameter, its value and the observed standard deviation σ has to be reported, as indicated in the tables of Appendix B.

6.3 Measurement and evaluation for type A2 artefact

A least squares mean line representing the upper level is drawn over the groove. A least squares circle is fitted through the centre third of the width of the groove. The depth *d* is evaluated from the line to the lowest point of the fitted circle (see Figure 2). The portions to be used for the evaluation are those shown at A, B and C in Figure 2. Five traces, evenly distributed over the measuring window, shall be taken and the average result together with the standard deviation σ shall be reported.

In order to evaluate the total profile height *Pt* (according to ISO 4287) the evaluation length should be limited to the equivalent region for the calculation of *d*, i.e. three times the groove width *w* without the transition zones.

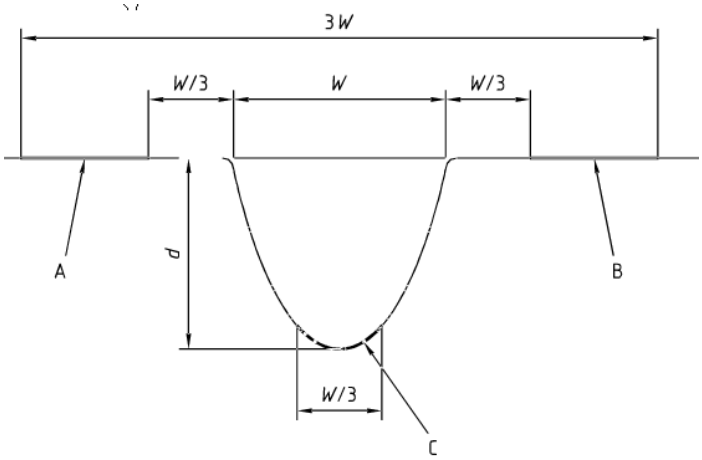


Figure 2 – Assessment of the depth measurement standard (ISO 5436-1)

6.4 Measurement conditions for type C1 and D1 artefacts

Twelve traces, evenly distributed over the measuring window, shall be taken and the average result together with the standard deviation shall be reported. A Gaussian filter according to ISO 11562 (replaced by ISO 16610-21:2011) has to be applied for evaluating the *R* parameters.

The following measurement parameters need to be respected:

Standard	**Evaluation length (mm)**	**λ_C (µm)**	**λ_S (µm)**	**Measuring force (mN)**	**Sampling spacing (µm)**	**Tip radius (µm)**
Type C1 PGN 10	4.00	800	2.5	< 1	≤ 0.5	2
Type D1 S/N 021	4.00	800	2.5	< 1	≤ 0.5	2
Type D1 KNT 2070/03	1.25	250	2.5	< 1	≤ 0.5	2
Type C1 SRM 2072	4.00	800	2.5	< 1	≤ 0.5	2

6.5 Evaluation of type F1 reference data

The following evaluation parameters need to be respected:

Standard	**File name**	**Evaluation length (mm)**	**λ_C (µm)**	**λ_S (µm)**	**□arameters**
F1 aperiodic	METAS_Aperiodic.smd	1.25	250	2.5	*Ra, Rq, Rz, Rt, Rsk*
F1 periodic	METAS_Periodic.smd	4.00	800	2.5	*Ra, Rq, Rz, Rt, Rsk, RSm*

The total profile length is 7 cutoff lengths (7 λ_c). The evaluation length l_n shall be the five central sampling length $l_r = \lambda_c$, thus removing one cutoff on each side in order to avoid end effects.

6.6 Measurement uncertainty

The uncertainty of measurement shall be estimated according to the ISO Guide to the Expression of Uncertainty in Measurement. The participating laboratories are encouraged to use their usual model for the uncertainty calculation.

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.

7 Reporting of results

7.1 Results and standard uncertainties as reported by participants

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

The measurement report forms in appendix 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 or electronically as a scanned pdf document. In case of any differences, the signed 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 within 3 months a first draft A.1 report on the comparison. This will be circulated to the participants for comments, additions and corrections.

8 Analysis of results

8.1 Calculation of the KCRV

The key comparison reference value (KCRV) is calculated as the weighted mean of the participant results. The check for consistency of the comparison results with their associated uncertainties will be made based on Birge ratio, the degrees of equivalence for each laboratory and each measurand with respect to the KCRV will be evaluated using E_n values (based on k = 2), along the lines of the *WG-MRA-KC-report-template*. If necessary, artefact instability, correlations between institutes, and the necessity for linking to another comparison will be taken into account.

8.2 Linking of result to other comparisons

LNE and INRIM will provide the link to EURAMET.L-K8.

Appendix A – Reception of Standards

To:	Ruedi Thalmann METAS, Lindenweg 50, CH-3003 Bern-Wabern, Switzerland Fax: +44 58 38 33 210 e-mail: rudolf.thalmann@metas.ch		
From:	NMI: ……	Name: ……	
	Signature: ……	Date: ……	

We confirm having received the surface measurement standards for the EURAMET.L-K8.2012 comparison 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 – Results Report Form

From:	NMI: ……	Name: ……
	Signature: ……	Date: ……

Type A2, KNT 2060/01, S/N 0589606

Groove	Parameter	Value (µm)	σ (µm)	u_C (nm)	ν_{eff}
R1 (d_{nom} 0.33 µm)	*d*				
	Pt				
R2 (d_{nom} 0.41 µm)	*d*				
	Pt				
R3 (d_{nom} 1.36 µm)	*d*				
	Pt				
R4 (d_{nom} 2.7 µm)	*d*				
	Pt				
R5 (d_{nom} 5.5 µm)	*d*				
	Pt				
R6 (d_{nom} 8.9 µm)	*d*				
	Pt				

σ: standard deviation
u_c: standard uncertainty
ν_{eff}: number of effective degrees of freedom (if estimated)

Type C1, PGN 10, no 682060 5

Parameter	Value (µm)	σ (µm)	u_C (nm)	ν_{eff}
Ra				
Rq				
Rz				
Rt				
RSm				

Type D1, S/N 021

Parameter	Value (µm)	σ (µm)	u_c (nm)	ν_{eff}
Ra				
Rq				
Rz				
Rt				

Type D1, KNT 2070/03, S/N 0986

Parameter	Value (µm)	σ (µm)	u_c (nm)	ν_{eff}
Ra				
Rq				
Rz				
Rt				

Type C1, NIST SRM 2072, S/N 1015

Parameter	Value (µm)	σ (µm)	u_c (nm)	ν_{eff}
Ra				
Rq				
Rz				
Rt				
RSm				

Type F1

Parameter	*METAS_Periodic.smd*	*METAS_Aperiodic.smd*
Ra (µm)		
Rq (µm)		
Rz (µm)		
Rt (µm)		
RSm (µm)		
Rsk		

Appendix C – Description of the measurement instrument

From:	NMI: ……	Name: ……
	Signature: ……	Date: ……

Make and Type of apparatus .....
.....
.....

Vertical measurement traceability: .....
.....

Transverse measurement traceability: .....
.....

Stylus .....

Manufacturer **:** .....
Radius **:** .....
Angle **:** .....
.....

Sampling spacing : .....
.....
.....

Speed : .....
.....

Measuring force : .....
.....
.....

Analysis Software : .....

Home made / commercial : .....
Version n° : .....
.....
.....
.....
.....

CMCs in the CIPM MRA : .....

Do you have CMCs published on the KCDB? .....
If yes, please indicate below the service identifiers and the uncertainties related to the quantities measured in this comparison:

NMI Service Identifier	CCL service category	Parameters	Range		$U(k = 2)$	Remarks
			Min.	Max.		
46	5.1.3	*Ra, Rq*	0.01 µm	10 µm	15 nm	Example
		Rz, Rt			30 nm	Example

(use additional pages as needed)