Project: COOMET 776/RU-a/19

COOMET.L-S28

Type of comparison: Supplementary

COMPARISON OF STANDARDS IN FIELD OF MEASUREMENT OF 3D PARAMETERS OF SURFACE TEXTURE

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INTRODUCTION

In accordance with the COOMET comparison program for 2019, comparisons of unit length standards in the field of measuring 3D surface texture parameters were carried out in 2019 on the topic COOMET 776/RU-a/19. Pilot laboratory: Russian Research Institute of Metrological Service (VNIIMS, Russia).

The measurement results of the standards and declared standard uncertainties are given in section 9 of this report.

1 Participants and schedule

Table 1

№	Country/NMI	Contact person/Address	Date of measurement
1	Russia, (Pilot laboratory) All-Russian Research Institute of Metrological Service (VNIIMS)	Vladimir Kosteev Department of metrological assurance for measuring geometric parameters 119361, Ozernaya str., 46, Moscow, Russia Tel.: +7 (495) 781-86-53 E-mail: milovanova@vniims.ru vkosteev@vniims.ru	August 2018
2	Belarus, Belarussian State Institute of Metrology (BelGIM)	Vladimir Makarevich Production and Research Department of measurements of geometric parameters Starovilensky tract 93, Minsk, 220053, Belarus Тел.: +375 (17) 233-35-82 Fax: +375 (17) 288-09-38 E-mail: makarevich@belgim.by	October 2018
3	Kazakhstan (RPG KazStandart)	Dulat Moldibaev 010016, Leviy bereg, Esil region, Mangilik el avenue 11 Nur-Sultan, Kazakhstan Tel. +7 (7172) 282 957 E-mail: moldybayev@kazinmetr.kz	June 2019

2 Organization of comparison

2.1 The aim of comparison is to establish the degree of equivalence between the national standards

2.2 Scheme of comparison – is circular.

2.3 The principle of comparison.

The participants of the comparison measure surface texture on the same site on their national standards in accordance with the requirements of the section "Measurement procedure".

Based on the results obtained for each standard, the following are calculated:

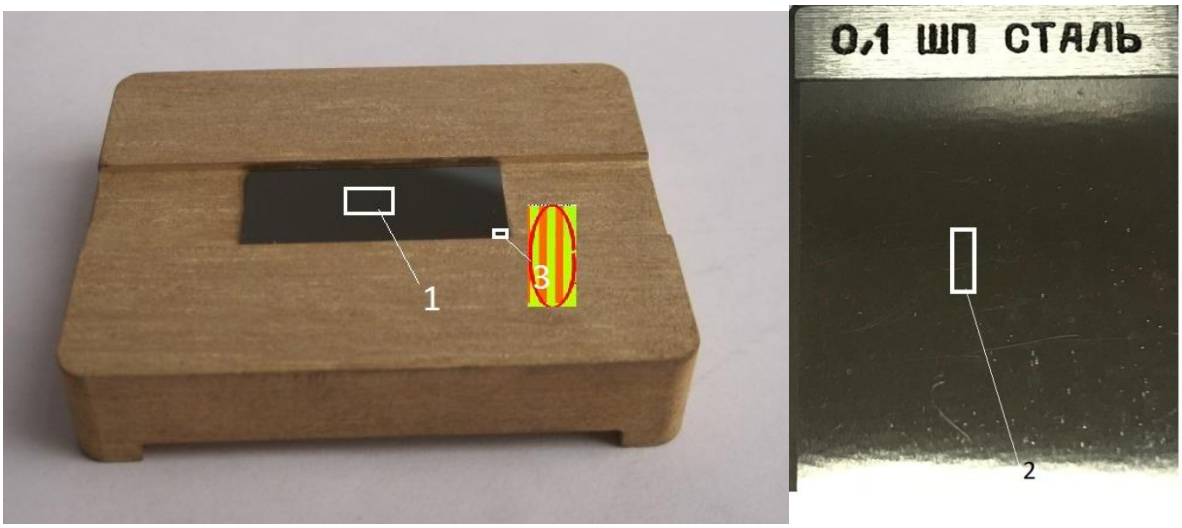
– the reference value;

– expanded uncertainty of the reference value;

– the degree of equivalence of standards.

3 Comparison standards (artefacts)

Two artefacts were used to carry out the work – PRO-10 with a nominal value of Ra = 1 μm and a comparison specimen of the technical surface (flat grinding) with a nominal value of Ra = 0.1 μm. The general view of the standards and the location of the measurement zones are shown in fig. 1.



Standard PRO-10 Comparison specimen of flat grinding

Figure 1 – The general view of the standards and the location of the measurement zones.

Because there were only 3 participants of this comparison, the condition of the artefacts was not checked additionally after they were received by the pilot laboratory.

The nominal values of the artefacts parameters are shown in Table 2.

Table 2

Artefact	Nominal value
PRO-10 (Roughness standard) Ra Sa	 1,0 μm 1,0 μm
PRO-10 (Depth standard)	2,2 μm
Flat grinding specimen Ra Sa	 0,1 μm 0,1 μm

4 Measurement procedure

4.1 To carry out measurements on each standard, an average zone of 5x4 mm was selected. To measure the depth of individual groove on the PRO-10 standard, a zone located in the lower right corner of the 0.9 × 0.9 mm standard was selected, and a 0.7x0.12 mm area was selected for further analysis (the location is shown in Figure 1).

4.2 Measurements were carried out on the artefacts, respectively, on zones 1 and 2 - ten measurements each, the size of the site is 0.9 × 0.9 mm, evenly spaced across the field of the zone and without overlap. A single measurement was carried out in zone 3. The array of received data of each measurement was saved for further processing and calculation of parameters.

4.3 For each measurement (in zones 1 and 2), the topographic parameter Sa was calculated using the Talymap program in accordance with ISO 25178-2. Next, the results were converted into a series of profiles and the profile parameters (Ra) were calculated. For each zone, the average value of the parameter and the standard deviation was calculated. The result of measuring zone 3 was also uploaded to the Talymap program, conversion into a series of profiles was carried out and the groove depth parameter was calculated in accordance with ISO 5436-1, the average parameter value and RMS were calculated.

5 Environmental conditions during comparisons

5.1 The environmental conditions under which the standards were measured are shown in Table 3.

Table 3

Environmental conditions	Acceptable values
Temperature range, °C	20 ± 1
Humidity range, %	40 - 50
Termal gradient limit, °C/h	1,0

6 Brief description of the standards

6.1 The general view of the BelGIM standard is shown in the fig. 2

Figure 2 – The general view of the BelGIM standard

The standard includes the following basic equipment:

– Talysurf CCI HD optical profilometer «Taylor Hobson» (Great Britain) with a set of lenses and Talymap Gold software;

– a set of standards for calibration of the piezo sensor.

6.2 The general view of the VNIIMS standard is shown in the fig. 3.

Figure 3 – The general view of the VNIIMS standard.

The standard includes the following basic equipment:

– Talysurf CCI 6000 optical profilometer «Taylor Hobson» (Great Britain) with a set of lenses and Talymap Gold software;

– a set of standards for calibration of the piezo sensor.

6.3 The general view of the KazStandart standard is shown in the fig. 4.

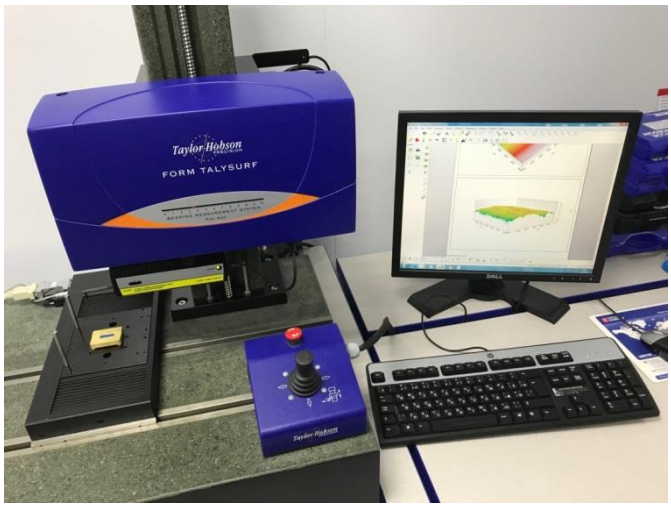


Figure 4 – The general view of the KazStandart standard

The standard includes the following basic equipment

– Form Talysurf PGI 420 stylus profilometer «Taylor Hobson» (Great Britain) with a sensor based on a phase scale interferometer;

– set of calibration standards and Ultra Roughness Software;

– additionally, a motorized table for transverse movement, Talymap software was used.

7 Comparison of the types of devices used in the standards

Table 4

Laboratory	Type of drive	The size of the measured platform, mm	Data processing system
VNIIMS	Calibrated piezo drive	0,9 × 0,9	PC, CCI management program, calculation program Talymap Gold software
BelGIM	Based on a phase scale interferometer	0,9 × 0,9 мм	PC, CCI management program, calculation program Talymap Gold software

Laboratory	Type of drive	The size of the measured platform, mm	Data processing system
KazStandart	Based on a phase scale interferometer	0,9 × 0,9 мм	PC, Ultra management program, calculation program Talymap Gold software

8 Mathematical models for measurement

8.1 The value of the height parameter of the surface is calculated by the formula:

$$Y = X_u + \delta_{RS} + \delta_S + \delta_{str} + \delta_{FR} + \delta_R + \delta_L + \delta_C$$

where

Y – height of the surface element, μm;

X_u – average arithmetic value of measurement results, μm;

δ_{RS} – uncertainty contribution caused by not taking into account the probe radius when calculating (for stylus instruments);

δ_S – uncertainty of the standard (standard deviation of mean arithmetic of standard), μm;

δ_{str} – uncertainty contribution caused by straightness deviation of the guide of the device (for stylus instruments);

δ_{FR} – uncertainty contribution due to repeatability, μm;

δ_R – uncertainty due to system resolution, μm;

δ_L – uncertainty due to nonlinearity of the piezo drive/sensor, μm;

δ_C – uncertainty due to the reference calibration standard's certificate value, μm.

9 Results of measurements

9.1 The results of measurements of standards show in Table 5.

Table 5

Standard	Parameter	Measurement result , μm			Declared combined standard uncertainty, μm		
		VNIIMS	BelGIM	KazStandart	VNIIMS	BelGIM	KazStandart
PRO 10 zone 1	Sa	1,024	1,035	1,054	0,0075	0,0075	0,012
	Ra	1,014	1,027	1,043	0,0070	0,0075	0,012
Flat grinding zone 2	Sa	0,131	0,150	0,125	0,0100	0,0090	0,012
	Ra	0,098	0,121	0,098	0,0080	0,0075	0,012
PRO 10 zone 3	h (depth)	2,207	2,210	2,210	0,0070	0,0070	0,012

10 Procedure for assessing the degree of equivalence of national standards, participating in comparisons

The weighted average value was the KCRV for each measurand. The measurement results performed by the participants of the comparisons were checked according to the En-criterion

To check the internal density between the results of individual measurements, the En-criterion was used. For k=2, *En* must be less than or equal to 1: $|En| \leq 1$.

$$E_n = \frac{1}{k} \cdot \frac{x_j - x_{ref}}{\sqrt{{u_j}^2 - {u_{ref}}^2}} \quad (1)$$

$$x_{ref} = \frac{\sum_{j=1}^{n} p_j \cdot x_j}{\sum_{j=1}^{n} p_j} \quad (2)$$

$$u_{ref} = \frac{1}{\sqrt{\sum_{j=1}^{n} \frac{1}{{u_j}^2}}} \quad (3)$$

$$p_j = \frac{1}{{u_j}^2} \quad (4)$$

$$U_j = 2 \cdot u_j \quad (5)$$

$$U_{ref} = 2 \cdot u_{ref} \quad (6)$$

where x_j – measurement result of laboratory *j*;

u_j – combined standard uncertainty declared by laboratory *j*;

p_j – weight of the measurement result declared by laboratory *j*;

x_{ref} – reference (weighted average) value of comparisons;

u_{ref} – combined standard uncertainty of reference value;

n – number of participants in comparisons;

U_j – expanded uncertainty declared by laboratory *j*.

Figure 5 and Table 6 show the results of comparisons by parameter Sa for standard PRO-10 (zone 1).

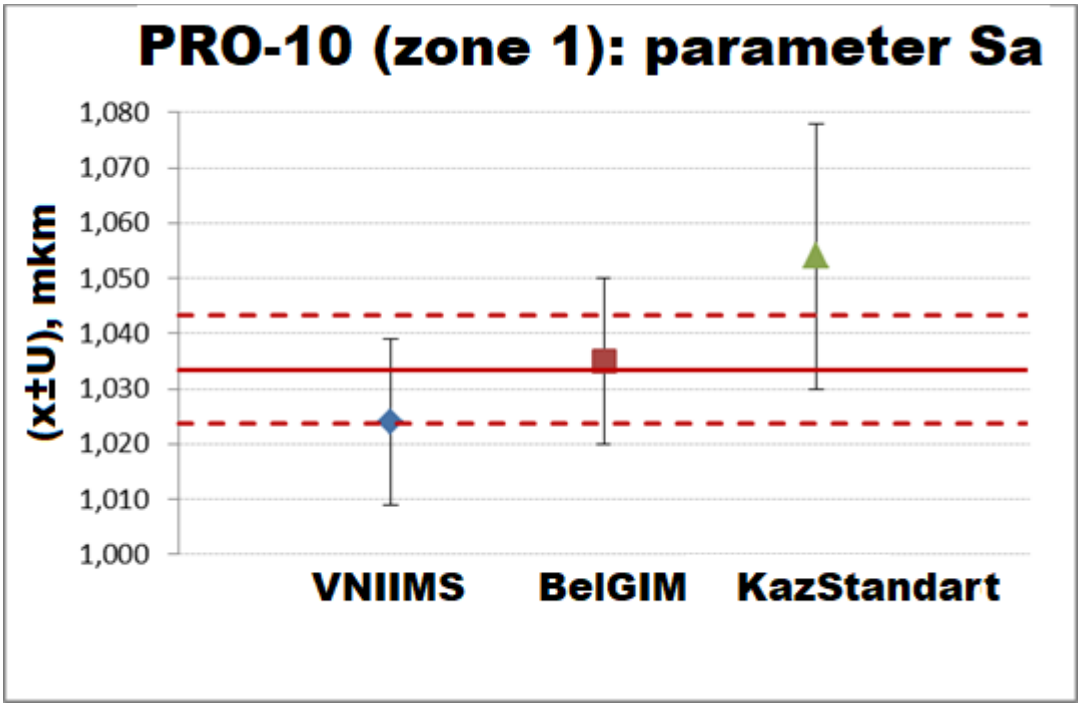


Figure 5 – Measured value of the Sa parameter in zone 1 PRO-10
(the red solid line is the reference value; the red dashed line is the extended uncertainty of the reference value)

Table 6

Characteristics	NMI		
	VNIIMS	BelGIM	KazStandart
Measurement result of laboratory x_j, μm	1,024	1,035	1,054
Combined standard uncertainty declared by the laboratory u_j, μm	0,0075	0,0075	0,012
Reference value (weighted mean value) x_{ref}, μm	1,034		
Combined standard uncertainty of reference value u_{ref}, μm	0,0049		
En value	-0,84	0,14	0,94

Figure 6 and Table 7 show the results of comparisons by parameter Ra for standard PRO-10 (zone 1).

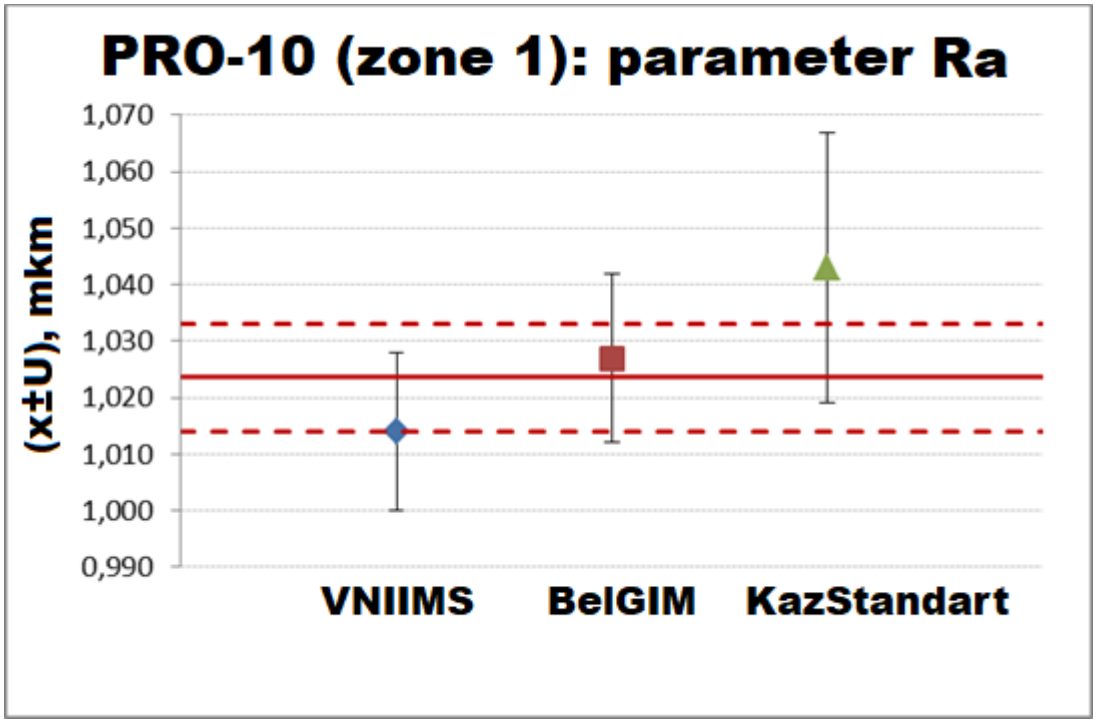


Figure 6 – Measured value of the parameter Ra in zone 1 PRO-10 (the red solid line is the reference value; the red dashed line is the extended uncertainty of the reference value)

Table 7

Characteristic	NMI		
	VNIIMS	BelGIM	KazStandart
Measurement result of laboratory x_j, μm	1,014	1,027	1,043
Combined standard uncertainty declared by the laboratory u_j, μm	0,0070	0,0075	0,012
Reference value (weighted mean value) x_{ref}, μm	1,024		
Combined standard uncertainty of reference value u_{ref}, μm	0,0048		
En value	-0,95	0,30	0,89

Figure 7 and Table 8 show the results of comparisons by the parameter Sa for the comparison specimen of flat grinding (zone 2).

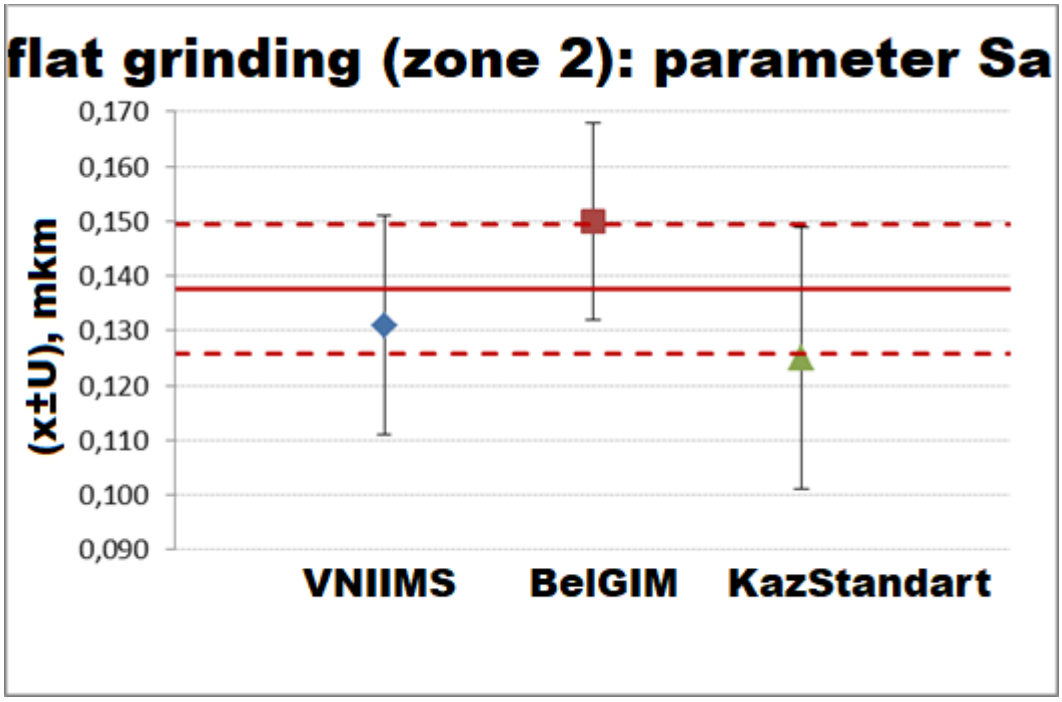


Figure 7 – Measured value of the parameter Sa in zone 2 flat grinding (the red solid line is the reference value; the red dashed line is the extended uncertainty of the reference value)

Table 8

Characteristics	NMI		
	VNIIMS	BelGIM	KazStandart
Measurement result of laboratory x_j, μm	0,131	0,150	0,125
Combined standard uncertainty declared by the laboratory u_j, μm	0,0100	0,0090	0,012
Reference value (weighted mean value) x_{ref}, μm	0,138		
Combined standard uncertainty of reference value u_{ref}, μm	0,0059		
En value	-0,41	0,92	-0,61

Figure 8 and Table 9 show the results of comparisons by the parameter Ra for the comparison specimen of flat grinding (zone 2).

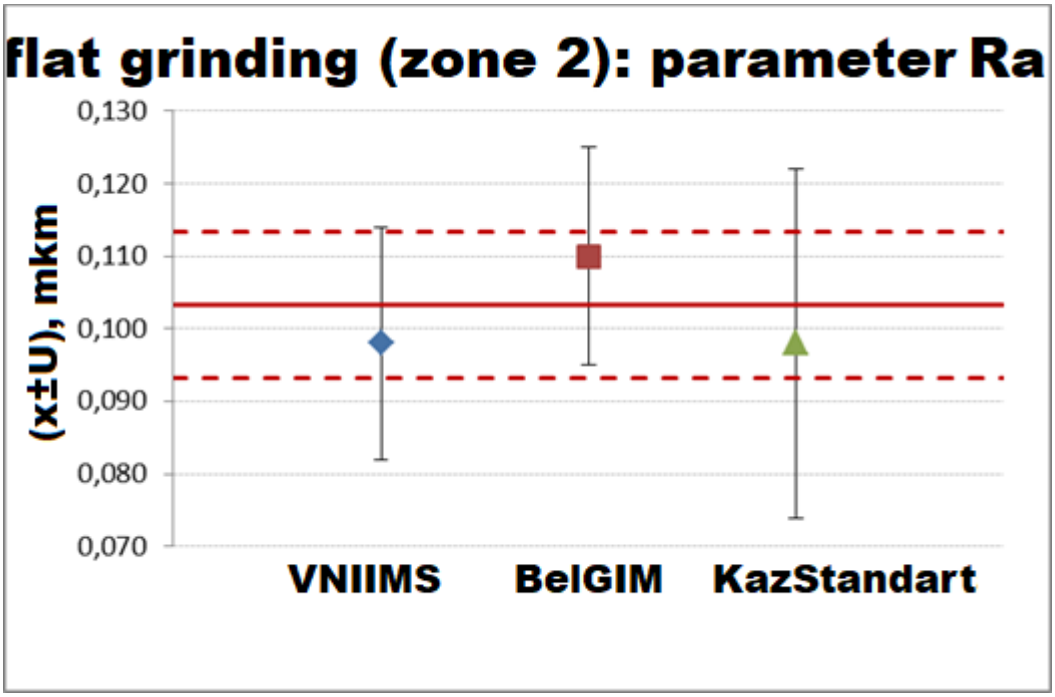


Figure 8 – Measured value of the parameter Ra in zone 2 flat grinding (the red solid line is the reference value; the red dashed line is the extended uncertainty of the reference value)

Table 9

Characteristics	NMI		
	VNIIMS	BelGIM	KazStandart
Measurement result of laboratory x_j, μm	0,098	0,110	0,098
Combined standard uncertainty declared by the laboratory u_j, μm	0,0080	0,0075	0,012
Reference value (weighted mean value) x_{ref}, μm	0,103		
Combined standard uncertainty of reference value u_{ref}, μm	0,0050		
En value	-0,43	0,61	-0,25

Figure 9 and Table 10 show the results of comparisons by parameter h (groove height) for standard PRO-10 (zone 3).

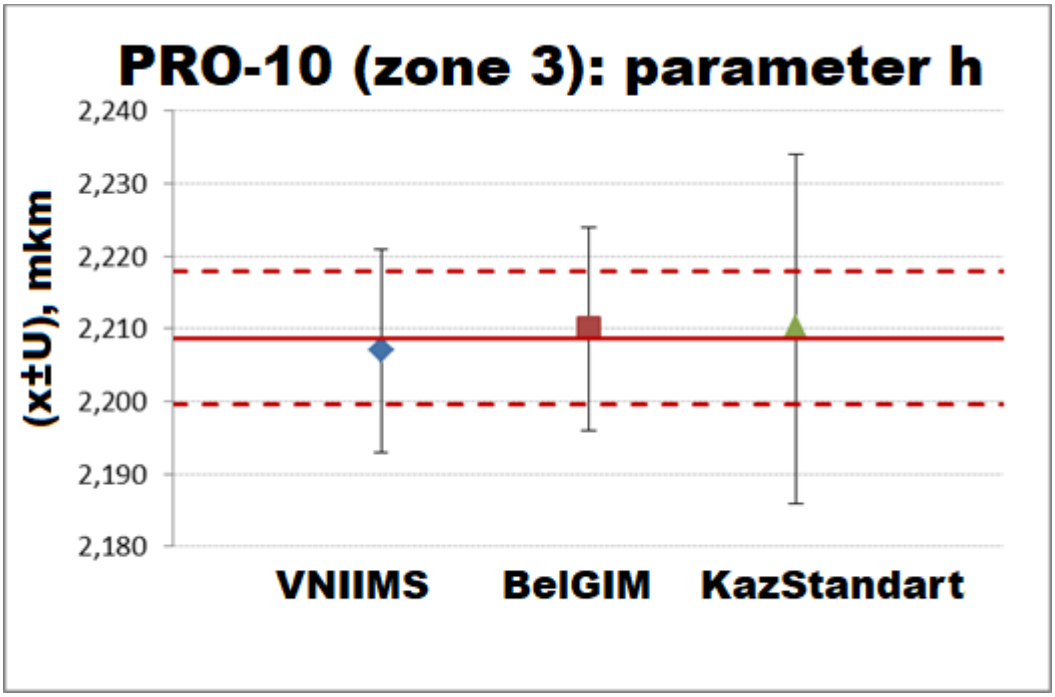


Figure 9 – Measured value of the groove depth in zone 3 PRO-10
(the red solid line is the reference value; the red dashed line is the extended uncertainty of the reference value)

Table 10

Characteristic	NMI		
	VNIIMS	BelGIM	KazStandart
Measurement result of laboratory x_j, μm	2,207	2,210	2,210
Combined standard uncertainty declared by the laboratory u_j, μm	0,0070	0,0070	0,012
Reference value (weighted mean value) x_{ref}, μm	2,209		
Combined standard uncertainty of reference value u_{ref}, μm	0,0046		
En value	-0,17	0,13	0,06

11 Correlation

The pilot laboratory (VNIIMS) calibrated their equipment (Talysurf CCI 6000) by step height standard (Type A1) which is calibrated by stylus profilometer. The calibration of stylus profilometer is done using a sphere which is calibrated by a length measuring instrument. Other participant KazStandart uses the same method and their sphere is calibrated by VNIIMS. Thereby through a chain of traceability, there might be a correlation between participants.

12 Conclusions

The calculated KCRV and En values are in compliance with the reported results and uncertainties of participants. No outliers are exist according to En value assessment. There is the full compatibility of all participants' results.

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[5] ISO 25178-2 Geometrical Product Specifications (GPS) – Surface texture: Profile method - Part 2: Terms, definitions and surface texture parameters

[6] ISO 5436-1:2000 Geometrical Product Specifications (GPS) – Surface texture: Profile method; Measurement standards – Part 1: Material measures