CURRENT STATUS OF VNIIM STANDARD OF UNIT IN THE FIELD OF GEOMETRIC MEASUREMENTS

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Abstract: The main areas of VNIIM domain in assurance of traceability of geometric parameters were described. Information concerning the current status and development perspectives of VNIIM reference base in linear and angle measurements is provided.

Keywords: state primary standard of the unit of length – meter, state primary standard of the unit of plane angle, reproduction and transfer of units, relevance, scope of accreditation, international comparisons.

D.I. Mendeleyev Institute for Metrology (VNIIM) is one of the basic divisions of the Federal Agency for Technical Regulation and Metrology of the Ministry of Industry and Energy of the Russian Federation. Founded in 1842, the Institute is the oldest metrological center in Russia devoted to the development and research of state standards, unique measuring instruments, as well as calibration, verification and testing of measuring instruments in various fields.

One of the main areas of metrological activity is to ensure the uniformity of measurements in the field of geometric parameters, which has become highly-demanded in by many branches of industry.

Currently, VNIIM has the modern reference base for metrological assurance of measuring instruments of length and plane angle, including the National primary standard of the unit of length – meter GET 2-2010, State primary standard of plane angle GET 22-2014 and 53 sub standards registered in the Federal Information Fund for Ensuring the unity of measurements [3].

Regardless of the type of measurement, the increasing requirements for metrological support indicate the need for the standard base to meet the current needs and maintain it at a high technical level.

In last decades the number of new measuring instruments of length and plane angle, based on various physical principles, has significantly increased. Such high-precision instruments of measurement as laser coordinate-measuring systems, tacheometers, digital autocollimators, angular and linear displacement encoders, and angle-measuring systems have appeared.

Multi-year research, analysis of data on modern methods and means of measuring of geometric parameters, as well as the experience of using similar standards of leading national metrology centers, allowed to solve the problems of metrological support taking into account the general development trend in the field of linear-angular measurements.

In the period from 2008 to 2010 the set of works was carried out to improve the National primary standard, originally developed in 1985, to improve the unit reproduction and expand the transfer range by creating a number of comparators. The main changes affected not only the inclusion of new setups in the National standard, but also the modernization of sets for measuring the laser frequency difference and the meter comparator. Currently, the state primary measurement standard is used in accordance with the State Verification Chain [1].

The main changes of metrological characteristics at the stages of improvement of the National primary standard of the unit of length-meter are presented in table 1.

Table 1. The main metrological characteristics of the state primary standard of the unit of length-meter

Name of characteristic	Approval date	
	1985	2010
The mean square deviation of the unit of length reproduction	$2 \cdot 10^{-11}$	$5{,}6 \cdot 10^{-12}$
Non-excluded systematic error	$1 \cdot 10^{-11}$	$2{,}2 \cdot 10^{-12}$
Length unit transfer range	$(1 \cdot 10^{-6} - 1)$ m	$(1 \cdot 10^{-9} - 30)$ m

Originally the National primary standard of the unit of plane angle, approved in 1972, was developed for the calibration of polygonal prisms and there was no setup to reproduce the unit of plane angle in its composition.

At present, the National primary standard of the unit of flat angle, approved in 2014, is a developed number of sets for reproduction, storing and transfer of the unit in static and dynamic modes in accordance with the State verification chain [2].

The main changes of the metrological characteristics of the National primary standard of the unit of flat angle after the work on its improvement are presented in table 2.

By the analysis of the data on the transfer of units of length and plane angle to the secondary and sub standards over the past three years the increase of works carried out on the standards to more than 1.5 times is observed. This is mainly due to the renewal of the park of linear-angle measuring instruments at the leading industrial enterprises and research organizations.

Along with the main activities related to the application and improvement of the National primary standards VNIIM performs verification, calibration and tests of measuring instruments for the pattern approval purpose, certification of the test equipment according to accreditation domain are carried out.

Table 2. Basic metrological characteristics of the state primary standard of the unit of flat angle

Name of characteristic	Approval date		
	1972	1980	2014
Range of values of the plane angle reproduced by the standard in static mode	-	(0-15)"	(0-15)"
Range of values of the plane angle reproduced by the standard in dynamic mode	-	-	(0-360)°
Reproduction of the unit of plane angle with the standard deviation of the measurement result (static mode)	-	0,01"	0,005"
Non-excluded systematic error (static mode)	0,02"	0,02"	0,0006"
Reproduction of the unit of plane angle with the standard deviation of the measurement result (dynamic mode)	-	-	0,01"
Non-excluded systematic error (dynamic mode)	-	-	0,021"

Not only the Primary standards are used for these works but some sub standards as well. Such as:

- horizontal length comparator with a measurement range from 10^{-6} to 1100 mm for metrological assurance of gauge blocks, reference rings and thread gauges (figure 1);

Figure 1 – Labconcept NANO 1100 Horizontal instrument

- multi-functional collimator stand VEGA UKS with an average square deviation of reproduction of horizontal and vertical angles no more than ±0,3'' to determine the metrological characteristics of geodetic measuring instruments (figure 2);

Figure 2 – Multi-functional collimator stand VEGA UKS

- device for measuring deviations from roundness and rotation surfaces disposal in the range ±1000 μm (figure 3);

Figure 3 – Measuring machine for measuring deviations from roundness MarForm MMQ 200

- thickness gauges in the range from 0,01 to 500 mm for verification and calibration of non-destructive control measuring instruments (figure 4).

The high level of ensuring the uniformity of measurements in the field of geometric characteristics is confirmed by the results of international standards comparisons with participation of leading national Metrology institutes.

According to the results of international comparisons of standards of length and plane angle, to date, calibration and measurement capabilities of VNIIM in these areas of measurements are confirmed by 16 lines of CMC database [4].

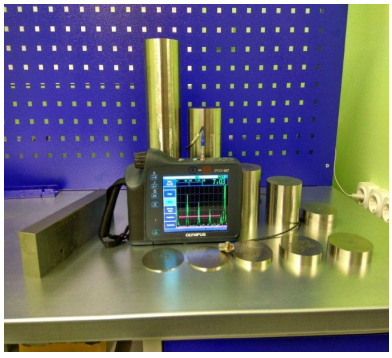

Figure 4 – Thickness gauges

In 2017 VNIIM took part in key comparisons of CCL-K4.2015 «Comparison of standards of diameters» on three parameters (internal and external diameters, deviation from roundness). At this stage the pilot-laboratory is preparing a preliminary report draft A.

Despite the high technical level of the reference base of VNIIM in the field of length and plane angle measurements, its further development is planned primarily for the expansion of calibration and measurement capabilities.

Since 2017 special attention has been paid to the development of a set of equipment for measuring the frequency (wavelength in vacuum) of lasers. This complex will allow to provide reproduction of unit of length in the range of wavelengths from 500 to 1050 nm with the frequency stability of the optical generator at least $5 \cdot 10^{-13}$ in 1 s. The complex includes comb generator (figure 5) and hydrogen time and frequency standard Ч1-1003М (figure 6). A stabilized laser at a wavelength of 633 nm produced by Winters Electro-Optics was placed in service as part of this work.

Figure 5 – Comb generator

At present its research is being carried out with the use of a reference radiation source from the State primary standard of a unit of length – meter.

It is planned to complete the work on the development and research of the complex with the subsequent approval of The state primary standard of the unit of length-meter in the new composition in 2019.

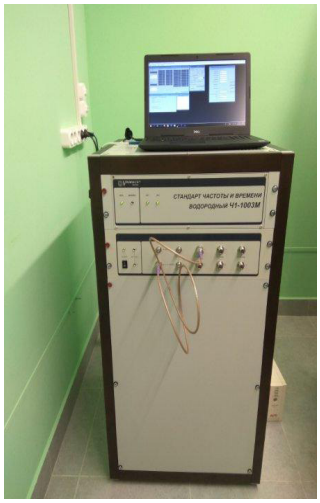

Figure 6 – Hydrogen time and frequency standard Ч1-1003М

References

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[2] Gosudarstvennaya poverochnaya skhema dlya sredstv izmerenij ploskogo ugla, utverzhdennaya prikazom Rosstandarta ot 19 yanvarya 2016 g. № 22.

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