

BENCHMARKING AND CALIBRATION OF MEASURING INSTRUMENTS. BASIC CONCEPTS

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Abstract. *This article analyzes the concepts of benchmarking and calibration of measuring instruments. The current regulatory documents and analysis of terminological definitions of measurements in accordance with state standards are presented. For the purposes of harmonization, this term was compared with the definition in international standards. The article presents the main terminological, methodological and algorithmic rules of the benchmarking and calibration procedure.*

Keywords: *measuring instrument, benchmarking, calibration, standard, error, uncertainty, method.*

The quality of the product and the accuracy of the measurement of physical quantities are inextricably linked. This is especially important for industrial enterprises, where even a few microns of a product dimension may be classified as defective. In order to carry out measurements with high accuracy, it is necessary to have high-precision measuring tools in enterprises that carry out benchmarking or calibration procedures in time.

Benchmarking of the measuring instrument is a set of operations performed by the metrology service aimed at evaluating and confirming the compliance of the measuring instrument with the specified requirements. In accordance with the Law "On Metrology", measuring instruments used in the field of state regulation of ensuring the uniformity of measurements must be compared. The benchmarking of measuring instruments is carried out by the accredited state metrology service and the accredited metrology services of state and economic management bodies. When comparing measuring instruments, determining and confirming their compliance with the established metrological requirements should be carried out on the basis of the methodology of comparing measuring instruments, which determines the sequence of operations. The list of categories of measuring instruments that must be compared in accordance with the law is approved by a specially authorized state body [1].

According to the state standard, there are the following types of benchmarking of measuring instruments:

- preliminary;
- periodic;
- out of turn;
- inspection;
- an expert.

Calibration of measuring instruments is a set of operations performed in order to determine the metrological characteristics of the measuring instrument by determining the ratio between the value of the quantity obtained using the measuring instrument under the given conditions and the value of the corresponding quantity restored by the standard.

Calibration is optional and can be carried out at the request of the enterprise and is carried out by the metrology services of legal entities or the enterprise itself.

Calibration can be carried out on measuring instruments that are not included in the scope of state regulation to ensure the uniformity of measurements, but on the condition that their metrological characteristics are controlled.

In terms of the process of benchmarking and calibration, they are similar and consist of comparing the reference and studied measurement methods to identify errors.

The main distinguishing features of calibration and benchmarking are as follows:

- calibration is not related to the conformity assessment procedure;
- benchmarking determines and confirms the compliance of the measuring instrument with the requirements, and calibration determines and confirms the true metrological properties of the measuring instrument [1,2,6].

The methods for comparing and calibrating measuring instruments are the same, but calibration can be easier or more difficult than checking.

1. Direct benchmarking method. It does not require additional equipment, it is very simple and has low accuracy, for example, measuring length with a ruler.

2. A benchmarking method using a comparator. In this method, a benchmarking device - a comparator is used, which should have high sensitivity and stability. It is used for indirect benchmarking of homogeneous and dissimilar physical quantities by substitution method.

3. Direct measurement method. This method uses direct measurements. This method is similar to the direct benchmarking method, provided that it is used over the whole-number range of the scale of a calibrated measuring instrument.

4. The method of indirect measurements is based on the detection of errors by an indirect method. It is used in cases where the error cannot be determined by the direct method or when the errors of indirect measurements are more accurate.

According to the law, calibration of measuring instruments is carried out by accredited metrology services. In the calibration of measuring instruments, the method of benchmarking of measuring instruments, designed to determine the metrological characteristics of the measuring instrument, is used. Measuring instruments used in fields other than those specified in paragraphs two to ten of the first part of Article 20 of the Law "On Metrology" may be calibrated during their production, sale, use, rental and repair [1,3].

Calibration results of measuring instruments performed by an accredited metrology service can be used for benchmarking of measuring instruments.

It is allowed to establish metrology services on the basis of public-private partnership for the calibration of measuring instruments.

The calibration procedure may vary. The following types can be distinguished:

- 1) by making changes to the systematic component of the error of the measuring instrument;
- 2) without making changes to the systematic component of the measuring instrument error;
- 3) benchmarking of the actual values of the error characteristics of the measuring instrument with the permissible values.

Based on these data, we can interpret the calibration as follows.

Calibration of measuring instruments is a set of operations that establish a relationship between the value of the quantity obtained using a measuring instrument and the corresponding

value of the quantity determined using a standard to determine the metrological characteristics of this measuring instrument.

The international dictionary interprets the concept of "calibration" in terms of the measurement uncertainty inherent in calibrated measuring instruments provided with working standards; the international definition of this word is extended by the need to estimate the measurement uncertainty during the tracking of the unit of magnitude to a national standard and calibration.

Calibration is a process during which, under the specified conditions, a ratio is established between the values of the quantities with measurement uncertainties provided by the standards at the first stage and indicators corresponding to their inherent uncertainties, and at the second stage, a ratio is established that allows obtaining this indicator based on the data of the measurement result indicators.

The international standard RMG 91-2009 contains recommendations and basic principles for the joint application of the concepts of "measurement error" and "measurement uncertainty" and the concepts derived from them in various metrological tasks. The concept of "measurement error" can be used when there is a single base value of a quantity that appears when performing calibration with a regulated value of a quantity that has measurement uncertainty, or when a standardized value of the quantity is given. In most metrological situations, measurement results are characterized by uncertainty, and the accuracy of measuring instruments is characterized by the errors of standards, measurement and control procedures. Thus, the concepts of "uncertainty" and "error" are compatible without contradicting each other and without excluding one of them [2,3,4,5]

So, from the above we can conclude that benchmarking and calibration are similar but there are differences. It is important to use benchmarking and calibration procedures, and one cannot be rejected in favor of the other.

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