UDC 921.01

IMPROVEMENT OF THE METROLOGICAL RELIABILITY ASSESSMENT OF THE INSTRUMENTS BY THE RESULTS OF GROUP TESTS

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Keywords: probability, metrological reliability,tests, error, instrument, cycles, trend, correlation.

Most national and international documents on standardization in metrology are devoted to ensuring the accuracy (correctness and precision) of measurement results by assessing the scattering characteristics of a measurement sample with the exception of systematic error. This is done, for example, when comparing standards, when measures are taken to eliminate systematic error in order to assess the true standardvalues within confidence limits determined by the rules of uncertainty theory.

This article discusses one of the ways to solve the no less urgent task of instrumentation - forecasting and monitoring the metrological reliability of toolsmeasurements according to the results of group tests.The basis for solving probabilistic problems are the principles used in assessing the reliability of machines. The difference is that as a diagnostic parameterthe systematic measurement error and its characteristics are applied.

In particular, the so-called stock of metrological reliability can be considered the most informative characteristic. It is a quantile of the two-parameter normal distribution *Z* of the probability of not reaching β of the error limit h_a, taking into account in the general case a change in both systematic h_{cn} and random σinstrument errors:

$$Z = \frac{h_a - h_{\text{сп}}}{\sigma_{\text{сл}}} \Rightarrow \beta = \text{cnorm}(Z). \quad (1)$$

The value of ha is determined by the supplier of the device, and the systematic h_{cn} and random σ errors are calculated from a sample of multiple measurements of the error hi with volume N,obtained during verification:

$$h_{\text{сп}} = \left|h_{\text{ср}}\right|, \quad h_{\text{ср}} = \sum_{i=1}^{N} h_i \Big/ N, \quad (2)$$

$$\sigma_{\text{сл}} = \sqrt{\frac{\sum_{i=1}^{N}\left(h_i - h_{\text{ср}}\right)^2}{N-1}}, \quad (3)$$

where $h_{cp}$is the average value of the error.

In the formula (1), the modules ha and hsp are used in order to correctly take them into accountpossible specular location in the negative zone of the scatter field.

The specified methodology for calculating stock of metrological reliability can be used when the initial vectorerrors are formed as a result of repeated measurements during individual tests of a particular device. Typically, this problem is solved during initial or periodic verification in order to allow the device to work. At the same time, to solve some problems of the assessment of stock of metrological reliability, it is necessary to test not one sample, but a group of similar instruments.

Consider the proposed methodology for solving one problem according to the results of grouptests to confirm the type of device. The problem can be formulated as follows: it is necessary to verify the possibility of reducing the volume of testing of devices designed to operate in various climatic conditions.

In this case, to confirm the type of device, the main test mode is set with a minimum systematic error ($h_a \approx 0$) after the device is aligned. AtIt is known that the error depends on changes in the operating conditions of the device (for example,with increasing temperature). It is required to determine whether the device should be checked under various operating conditions or whether it is possible to limit oneself to tests in the main mode. Atthis criterion for the health of the device is compliance with the three sigma rule, when forstock of metrological reliability the following condition is met

$$Z \geq Z_{\text{доп}} = 3, \tag{4}$$

where $Z_{доп}$ is the permissible level of stock of metrological reliability.

The object of the test are m devices of the same type (take m = 5). The solution to the problem is divided into two stages. On the first, an error limit is set h_a = 10. For each j-th device, multiple measurements of the absolute or relative error hisample size N (e.g., N = 10). Thus, 5 samples of measurements with a volume of 10 cycles are obtained. For each of them, a systematic and random error is calculated according to formulas (2) and (3), and then stock of metrological reliability according to formula (1). To increase confidenceestimates, all five vectors should be combined into a sample of volume mN = 5 =10 = 50 elements,then, the systematic and random errors of the combined (about) sample are calculated. In this case, you can apply the formulas:

$$h_{\text{об.сп}} = \left| h_{\text{об.ср}} \right|, \quad h_{\text{об.ср}} = \sum_{j=1}^{m} h_{\text{сп.}j} \Big/ m, \tag{5}$$

$$\sigma_{\text{об.сл}} = \sqrt{\frac{\sum_{j=1}^{m} \left[\sigma^2_{\text{сл}\,j} (N-1) + N h^2_{\text{ср}\,j} \right] - mN h^2_{\text{об.ср}}}{mN-1}}. \tag{6}$$

In conclusion, for the combined sample, the stock of metrological reliability is calculated by the formula (1), whichmust meet condition (4).