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MATHEMATICAL ALGORITHM FOR PREDICTING THE CALIBRATION INTERVAL AND METROLOGICAL ACCURACY OF GAS ANALYZERS BASED ON INTERNATIONAL RECOMMENDATIONS ILAC-G24:2022/OIML D 10:2022 (E)

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Abstract: This research work analyzes the issues of establishing the calibration interval of measuring instruments and predicting metrological accuracy. The issue of implementing the methods given in the international recommendations ILAC-G24:2022/OIML D 10:2022 (E) using experimental measurements is considered. In order to analyze the calibration process over the years, the maximum permissible limits of measurement accuracy were determined, decision rules were introduced, and factors influencing the results were studied. Based on the results of calibration of the gas analyzer "KASKAD-N 31.4" for the oxide component of nitrogen in 2022 and 2023, the expected calibration period is predicted in 2024. Based on the results of theoretical and experimental analysis, an algorithm for predicting the calibration interval was formed.

Key words: Calibration interval, international recommendation ILAC-G24:2022, metrological control, decision rules, primary calibration, gas analyzer "KASKAD-N 31.4".

I. Introduction. If the results of any control and verification are assessed as negative or positive, during metrological checks of measuring instruments, they include the question of maintaining the operability of the measuring instrument, operating without defects, and maintaining its metrological characteristics within specified limits. The time interval is also considered important. We know that when comparing measuring instruments, their list and periodic comparison period are indicated on the basis of a list approved by the competent authorities of the state [2]. Currently, according to the legislation of the Republic of Uzbekistan and regulatory legal documents, calibration intervals are determined by the user of the measuring instrument, and it is recommended to use methods for predicting the interval of results taking into account indicators, the use of this measuring instrument complies with international standards and requirements. The main purpose of International Recommendation ILAC-G24:2022 is to provide guidance to laboratories in determining calibration intervals, especially when setting up their calibration system [1].

Theoretical part.

After the initial calibration of the measuring instruments, the next calibration interval should be determined by a qualified laboratory technician. When making a decision, the competent employee takes into account the following [5;6;7;8]:

- measurement uncertainty required and estimated by the laboratory;
- type of measuring instruments and their components;
- the risk of exceeding predetermined limits of the measuring instrument or accuracy requirements when using it;
- manufacturer's recommendations for measuring instruments;

- tendency to wear and tear;
- expected level and severity of use;
- environmental conditions;
- the influence of the measured quantity on the measuring instruments (for example, the effect of high temperature on thermocouples) on the measurement results;
- consolidated or published information about the same or similar devices;
- frequency of comparison with other standards or measuring instruments;
- frequency, quality and results of intermediate checks;
- the procedure for transporting measuring instruments and the risks associated with them;
- the level of training of operational personnel and the degree of implementation of established procedures;
- legal requirements.

Based on these factors, assessments are made throughout the life of use and the laboratory may set an initial calibration interval, provided that this period is not exceeded by law.

If we take into account that the frequency of metrological control of gas analyzers is set at 12 months based on the legislation of the Republic of Uzbekistan and in accordance with paragraph 5.1 of the international recommendation ILAC-G24:2022, laboratories using gas analyzers must establish a primary calibration interval within a period not exceeding 12 months . If this period exceeds 12 months, the metrological traceability of the results presented in laboratory studies becomes uncertain, which increases the risks affecting the results.

Based on the international recommendations ILAC-G24:2022, we need to choose one of the following methods for determining the post-initial calibration interval of gas analyzers:

- Method 1: Automatic adjustment or “ladder” (calendar-time);
- Method 2: Control table (calendar-time);
- Method 3: “Use” time;
- Method 4: Functionality check or black box check;
- Method 5: Other statistical approaches.

The most common method for estimating the post-initial calibration interval is the ladder method, in which the calibration interval is continuously increased or decreased at shorter intervals than the previous one. In the checklist method, regular checks are carried out on the basis of a set schedule. In the use method, the calibration interval is determined by comparing the total operating time of the measuring instrument with each time used [1].

If the metrology testing laboratory provides practical assistance in determining the calibration interval as a recommendation, then method 1 of the ladder method is considered the most appropriate method. In this way, the next calibration interval can be predicted based on changes in metrological characteristics, regardless of how the measuring tool is used.

When statistically evaluating the results, as a result of a series of theoretical and experimental studies, it is possible to consider increasing or decreasing the calibration interval. First of all, let's divide the required limit of maximum permissible deviations of the measuring instrument, which determines the calibration interval, into 2 parts (Fig. 1) and develop decision-making rules for ourselves based on the risks affecting the measurement results [3].

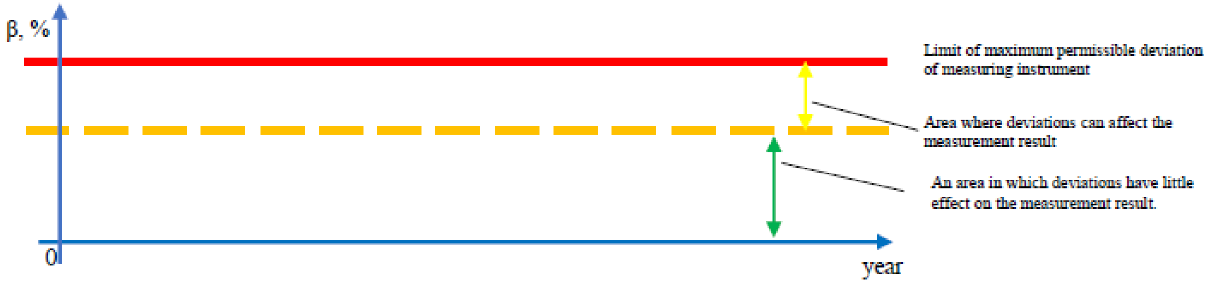

Figure 1. Distribution of the required maximum permissible deviation of the measuring instrument.

It is not recommended to use a measuring instrument if the calibration results of the measuring instrument exceed the required maximum permissible deviations of the measuring instrument.

It is necessary to reduce the calibration interval if the measuring instrument specifies a calibration interval after the initial calibration interval, and the results of the second and subsequent calibrations are in an area where deviations could affect the measurement result [4]. The reason is that these deviations are in an area that can affect the results specified by the laboratory or the developers of the measuring instruments; at any time there is a risk that minor changes will go beyond the maximum permissible deviations required by metrological standards. characteristics of the measuring instrument [3].

The calibration interval can be increased if the results of the second and subsequent calibrations are in an area where deviations have little effect on the measurement result. The duration of the increase in the interval can be 1.5 or 2 times compared to the previous one.

Results. If we consider the theoretical provisions in the experimental results, then in Table. 1 shows the results of calibration of the gas analyzer "KASKAD-N 31.4" for 2022 and 2023 for the nitrogen-oxide component.

Table 1. Calibration results of the gas analyzer "KASKAD-N 31.4" for 2022 and 2023.

Calibration points mg/m3	Deviation from results		Uncertainty		Uncertainty and deviation (relative uncertainty, %)			
	2022	2023	2022	2023	2022		2023	
10	0,3	0,4	0,12	0,15	0,18 (1,8)	0,42 (4,2)	0,25 (2,5)	0,55 (5,5)

20	0,5	0,6	0,13	0,14	0,37 (1,85)	0,63 (3,15)	0,44 (2,2)	0,74 (3,7)
30	0,7	0,9	0,12	0,17	0,58 (1,93)	0,82 (2,77)	0,73 (2,43)	1,07 (3,57)

We place the results (Fig. 1) of this table on the distribution graph in Fig. 2. The maximum permissible deviation limit required here is defined as β=25%, assuming that the risk of the calibration result influencing the laboratory's measurement result is 0.8 factors, while the initial limit of the area in which deviations can affect the measurement result , will be 0.8β=20.

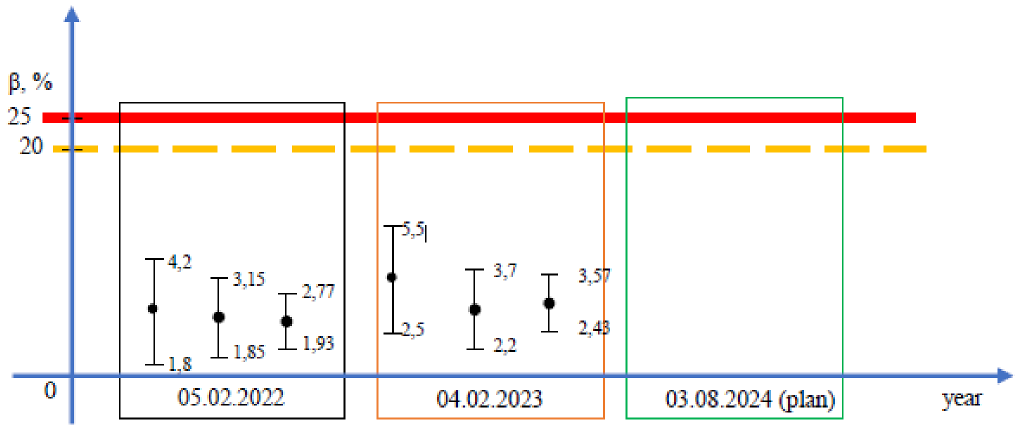

Figure 2. The result of calibration of the gas analyzer "KASKAD-N" for 2022 and 2023.

From the above results, it can be seen that the result of the 2023 calibration is not much different from the result of the 2022 calibration, and these results are not in the range of deviations that can affect the measurement result, from which it can be concluded that the calibration interval for 2024 can be leave unchanged or increase by 1.5 times.

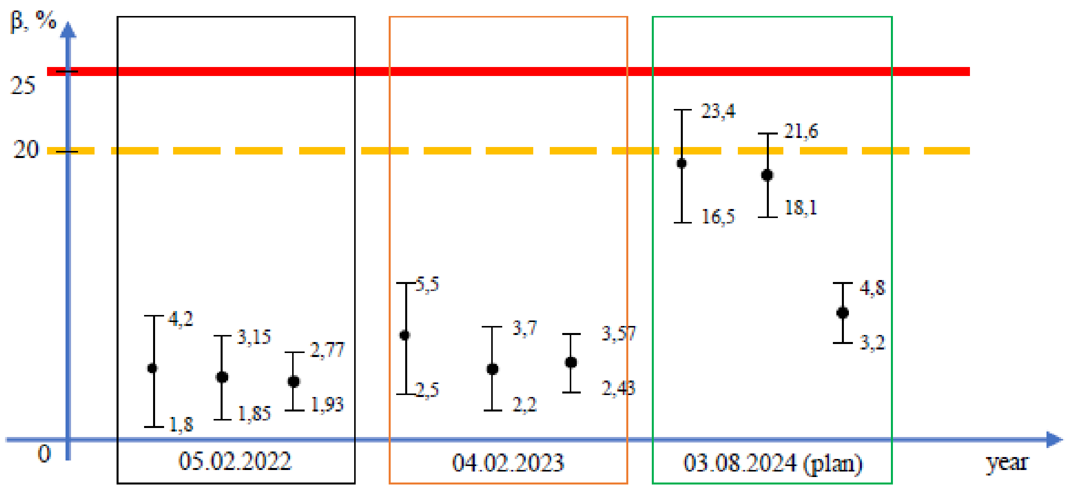

Figure 2. Approximate results of the gas analyzer "KASKAD-N 31.4" for 2024

If the result of the 2024 calibration is as in Fig. 3, then it is necessary to shorten the calibration interval and analyze the magnitude of deviations in the results.

Conclusion. Based on the above theoretical and experimental analysis, an algorithm for determining the calibration interval is developed, as shown in Figure 4.

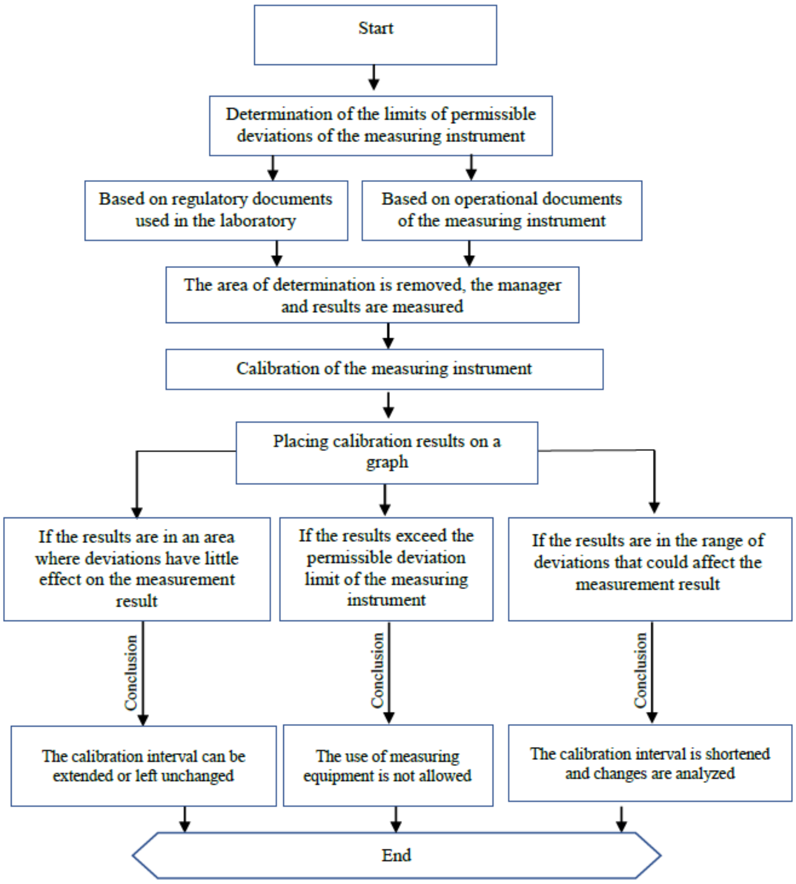

Figure 4. Calibration Interval Prediction Algorithm.

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