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Accuracy and Traceability Control of the Gas Pressure Measurement Instruments

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ABSTRACT:The article presents the implementation of the technically sound approach for the requirement selection of the permissible error of gas pressure calibration. The article discusses the calibration of gas pressure measurement instruments, calibration accuracy criteria and parameters of the calibration procedure. To test the analysis of the accuracy of gas pressure calibration measuring instruments, the error calculation formula and method are given.

KEYWORDS: Classification, Data Mining, Machine Learning, Predictive analysis, Social Networking Spam, Spam detection.

I. INTRODUCTION

The characteristic feature of gases is that they do not have their volume and shape, but take the form and occupy the volume of the vessel in which they are placed. Gases evenly fill the volume of the vessel, trying to expand and take as much as possible. All gases have high compressibility. Molecules of real gases have a volume and have mutual attraction forces, although these values are very small.

The relationship between density, temperature and pressure is established by the equation of state, which for real liquids and gases is derived in the kinetic theory. However, due to the complexity of the General equation of state and the difficulty of determining the constants included in it, approximate theoretical or empirical equations are used for qualitative analysis of the properties of these media. Expressing the density of gas through pressure, as well as the speed of sound through pressure, we have such a connection between the speed of gas and the pressure before the hole in the pipe.

To determine the metrological characteristics of measuring instruments (MI) and confirm their compliance with the established requirements, SI calibration (verification) is carried out, including SI for determining the gas pressure - a set of operations performed by the bodies of the metrological service in order to establish the suitability of MI for use.

Traceability of measurements means the results of measurements or the value of the norm, on the basis of which it (the result, the value) can be attributed to established standards, usually national or international standards, through an indissoluble chain of comparisons, each of which is characterized by an established uncertainty of measurements. This requires the calibration of measuring instruments.

Calibration of measuring instruments - a set of operations performed in order to determine the actual values of the metrological characteristics of measuring instruments and is performed mainly by metrological services of legal entities using standards, subordinated to the state standards of units.

The main metrological characteristic of measuring instruments for the determination of gas pressure (instrument) is the basic error. Limits of acceptable basic error of the device are expressed as a percentage of the measuring range or the upper limit of measurement and range from ±0,1 to ±1,5 %.

The basic error is determined in the following ways: exemplary SI at the input of the sensor set measured parameter, equal to the nominal, and in another exemplary SI measured value of the output signal; according to an exemplary SI at the output of the sensor, establish the calculated value of the output signal corresponding to the nominal value of the measured parameter, and according to another exemplary SI to measure the value of this parameter at the input of the sensor; comparing the output signals of check and reference sensors.

The basic error is defined as the maximum deviation of the actual values from the calculated ones. The presence of errors in the reference MI, as well as errors in the calibration method leads to the fact that there is always a calibration error that will affect the calibration result.

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It is obvious that because of calibration errors, two types of errors are possible: there is a risk to accept as a defective actually usable MI (fictitious marriage), or as a valid actually defective SI (undetected marriage). Error in the first case is considered to be a mistake of the first kind, and in the second - a mistake of the second kind.

It is obvious that the errors of the first and second genera have different meanings for manufacturers and consumers (customers) of controlled products.

The presence of undetected marriage is dangerous because the SI will be used, the error of which exceeds the permissible value. As a result, the error of measurements carried out with the help of this MI increases, and the required accuracy and reliability of measurements will not be provided.

Fictitious marriage is dangerous for SI manufacturers (during primary calibration) and enterprises operating SI (with periodic calibration), as this leads to additional costs for repair, adjustment, rechecking of actually usable SI.

The decrease in the level of marriage correction can be achieved by reducing errors of calibration (to use a more accurate standard instruments, to change the method of calibration, to tighten the requirements for calibration, etc.). In practice, however, this reduction has certain limits, due to several techno-economic factors: the availability of standard instruments of the required accuracy, the inaccuracy of the methods applied for calibration, etc.

Another way of reducing the marriage of the calibration is to establish a test of tolerance by introducing some coefficient of contraction for margin of error verified SI. The introduced coefficient reduces the probability of the second kind error as the most dangerous one.

Under these conditions, a technically sound approach is needed to establish requirements for the permissible calibration error, ensuring its required reliability.

For the basic criteria of the validity of the calibration is accepted:

- the greatest probability of erroneous recognition of any valid defective instance of SI P_{bam} (undetected marriage);

- the ratio of the greatest possible module of the controlled characteristic of the error of SI WHICH can be mistakenly recognized suitable, to the limit of its admissible values $(\delta_m)_{ba}$ (the greatest exit for the admission);

- the greatest average for the set of suitable copies of SI the probability of erroneous recognition of defective actually fit copies of SI $(P_{gr})_{m\bar{g}}$ (fictitious marriage).

When selecting the permissible values of criteria of the validity of the calibration should be guided by techno-economic data based on the destination and application-specific SI. Permissible values $\{P_{bam}\}_p$ and $\{(\delta_m)_{ba}\}_p$ should be specified in the NDT containing the method of calibration of MI.

It is recommended to take $\{(\delta_m)_{ba}\}_p$ no more than 1.35 - for SI, the basic error of which is a small (less than 1/5) share in the measurement error; no more than 1.25 - for SI, the basic error of WHICH makes the same contribution to the measurement error as all other components; no more than 1.15 - for SI used for measurements, the error of which is almost completely determined by the basic error of SI; no more than 1.00 - if it is known that such SI is used for responsible measurements, when it is impossible to allow the output of its basic error for the permissible value.

A graphical illustration of the criteria is shown in Fig.1, where $\chi = \frac{Q}{|G_p|}$ -the ratio of the value of the controlled characteristic Q to the module of its maximum permissible value G_p (figure illustrates the case when $\varphi \geq 0$); $L(\chi)$ - conditional probability of recognition of the verifiable instance of SI suitable, provided that it has some specific value; $\chi = 1$ - normalized (in the shares of the module G_p) border, to the left of which is the χ range of values for valid instances of SI, to the right-for defective SI; $\beta = \frac{G_\beta}{|G_p|}$ - normalized boundary of such values Q for which negative results of a control (instance of C is recognized to be defective), it is recommended to regarded as incorrect.

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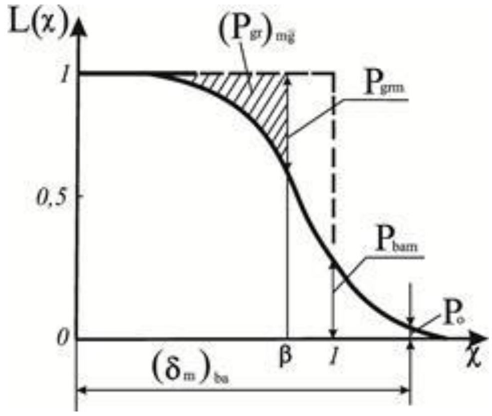

Fig.1. Calibration validity criteria diagram

The criterion P_{bam} corresponds to the ordinate of the curve $L(\chi)$ at the point. The criterion $(\delta_m)_{ba}$ corresponds to the abscissa of the curve $L(\chi)$ at which its ordinate is P_o equal to (or almost close to) zero. At the same $(\delta_m) = \frac{Q_m}{|G_p|}$ time, where Q_m is the highest possible value of the controlled characteristics Q of the SI instance, which can be mistakenly recognized as fit with probability P_o. The most acceptable range for P_o values is from 0 to 0,05.

The criterion $(P_{gr})_{m\bar{g}}$ corresponds to the area shaded in the figure, which numerically characterizes the ratio of the number of the mistakenly $(0-\beta)$ rejected SI specimens in the region to their total number in the region $(0-1)$. The area from 0 to 0,05 is to be considered as the most acceptable area for the criterion $(P_{gr})_{m\bar{g}}$ the value $(P_{gr})_{m\bar{g}}$ should not exceed 0,3.

The dashed line in the figure shows the ideal operational characteristic that would have occurred with an ideal calibration method. The type of real operational performance is completely determined by the calibration procedure and its parameters. The criterion P_{gm} corresponds to the addition of the ordinate of the curve $L(\varphi)$ to one at a point $\chi = \beta$. Selection of the area $0 \le \chi \le \beta$, i.e. $\beta < 1$ acceptance makes sense in cases where the controlled characteristic can change after the control so that soon after the control it is possible to go beyond the tolerance field. Introduction $\beta < 1$ as it takes into account the interest of the consumer that the instances of MI, controlled characteristics of which are close to the limits of the tolerance field, were recognized (with some probability) defective $\beta = 1$. Otherwise, accepted . The recommended β value is 0.8.

Consider the parameters of the calibration technique.

1. The number and location of control points in the measuring range of SI; determined by the nature of the function $\Delta_{os}(x)$ - the dependence of the systematic component of the Δ_{os} basic error of SI from the input signal x. In a normalized form, this dependence has the form $\chi_{os}(x) = \Delta_{os} / |\Delta_{os}|$, where Δ_{os} - the limit of the permissible systematic component of the basic error of SI. The choice of the number of test points is based on the condition that for any SI instance Ω the difference between the highest value of a continuous function $\chi_{os}(x)$ and its highest value in the test points satisfies the condition $\Omega \le \Omega_p$, where the permissible value Ω_p is usually equal to 0.05 or 0.1. The number of control points m at the specified usually Ω_p does not exceed 5 - 6 for a sufficiently large class of occurring $\Delta_{os}(x)$ functions, having the following properties: their implementations change smoothly enough , within

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the range of measurement SI do not exceed one or two full oscillations and are described by a trigonometric or power polynomial no higher than the third degree.

The number of control points significantly affects the probabilistic characteristics of the calibration. If a valid MI can be mistakenly rejected even when calibrated at one point m, the probability of such an error increases significantly at the verifiable points.

With the probability of rejection of a suitable SI P_{gr} at one point, the average probability of its rejection at the m points will be equal $P_{grm} = 1-(1-P_{gr})^m$.

For example, for $P_{gr} = 0{,}05$ and $P_{gr} = 0{,}1$ (when $m=1$) the values P_{grm} are

m	1	2	5	10
$P_{grm}(P_{gr} = 0{,}05)$	0,05	0,1	0,23	0,4
$P_{grm}(P_{gr} = 0{,}1)$	0,1	0,19	0,41	0,66

On the other hand, an unusable MI can only be released if there is a joint calibration error at all points P_{bam} in the range, so the average probability of this error decreases sharply with increasing m: $P_{bam} = P_{ba}^m$..

For example, for $P_{ba} = 0{,}05$ and $P_{ba} = 0{,}5$ (when $m=1$) the values P_{bam} are

m	1	2	5	10
$P_{bam}(P_{ba} = 0{,}05)$	0,05	0,0025	$3\cdot10^{-7}$	10^{-13}
$P_{bam}(P_{ba} = 0{,}1)$	0,5	0,25	$3\cdot10^{-2}$	10^{-3}

2. The number of observations at the test n point; when calibrating objects with an insignificant random component of the basic error and for $n=1$ objects with a significant random component of the basic error $n>1$.

3. A parameter α_p equal to the ratio of the limit of permissible calibration Δ_{Ip} error to the limit of permissible value of the basic error SI Δ_{cp}; limit values are selected from α_p the series: 1/10; 1/5; 1/4; 1/3; 1/2,5; 1/2. In the particular α_p case, it is the ratio of errors of the reference and verifiable SI α_p, which is set in the verification schemes. When calibrating the SI, it is necessary to establish a ratio that would ensure compliance with the requirements: $P_{bam} \geq \{P_{bam}\}_p$ and $(b_m)_{ba} \leq \{(b_m)_{ba}\}_p$. This is possible only if the error value obtained during calibration is not compared with the maximum permissible error Δ_{cp} of the measuring instrument $\Delta_{c\gamma}$, but with the control tolerance, which is determined by the parameter γ by the formula $|\Delta_{o\gamma}| = \gamma|\Delta_{cp}|$.

4. The parameter γ is equal to the absolute value of the ratio of the boundary of the control tolerance field to the module of the permissible value of the characteristic; the value γ is set based on the criteria of calibration reliability and the selected value α_p.

According to the set values α_p, you can select the required accuracy reference SI, and the set values γ the position of the control boundary, providing the required characteristics of reliability.

The basis for determining the parameters of calibration techniques are the tables given in MI 188-86 " GSI. Setting the values of the parameters of verification methods", reflecting the relationship of the reliability criteria P_{bam}, $(\delta_m)_{ba}$ with the parameters α_p and γ. Tables are made for different types of SI (measures, measuring instruments, etc.) α_p and γ depending on the significance of the random component and changes in the systematic component of the basic error of the verified SI. The use of tables simplifies the procedure of establishing the permissible calibration error.

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Parameter values α_p and γ are set in the following order. For the given values of the reliability criteria $\{P_{bam}\}_p$ and $\{(\delta_m)_{ba}\}_p$ draw the boundary of the area within which the values are α_p and γ to ensure the fulfillment of the basic requirements: $P_{bam} \geq \{P_{bam}\}_p$ and $(\delta_m)_{ba} \leq \{(\delta_m)_{ba}\}_p$.

The results obtained allow us to analyze the reliability of the calibration of SI depending on the accuracy of the reference SI available in the laboratory. For example, if the developer has established that a value can be realized $\alpha_p = 1/3$ (the ratio of errors of the reference and verifiable SI), it follows from the obtained series that the average probability of erroneous recognition of the defective MI will be 2.8%, i.e., $(P_{gr})_{m\bar{g}} = 0{,}028$ and the control tolerance will be 0,86 of the permissible error of the verifiable MI , i.e. $\Delta_{o\gamma} = 0{,}86\Delta_{op}$.

If the developer has determined that only the value $\alpha_p = 1/2$ can be realized, in this case, the average probability of erroneous recognition of a defective suitable SI will already be 27,1 %, and the control tolerance will be 0,65 of the permissible error of the verifiable SI, i.e., $\Delta_{o\gamma} = 0{,}65\Delta_{op}$ etc.

II. CONCLUSION WORK

Thus, a purposeful search for such values of the calibration procedure parameters α_p and γ (hence, calibration errors), which would provide acceptable values of the calibration reliability criteria (errors of the first and second genera).

A negative consequence of the narrowing of the control standards is a sharp increase in the probability of erroneous rejection. To avoid this, it is necessary to apply reference SI higher accuracy with moderate reductions in standards. In some cases, it is advisable to move from single to multiple measurements.

One of the main indicators of calibration reliability is the ratio of permissible errors of reference and verifiable SI. The higher the ratio, the more reliable the calibration. Ideally, this ratio should be 1:10. However, its achievement in practice is associated with high economic costs.

Analysis of the validity of calibration - this is one of the issues that require consideration in the development of calibration techniques. Attention should also be paid to the calculation (correction) of the calibration interval in the case of periodic calibration based on the simulation of the drift of the metrological characteristics of SI; processing and presentation of the measurement results in terms of the classical theory of accuracy and from the standpoint of the uncertainty theory. These issues are the subject of further research.

REFERENCES

[1] The reference manual for employees of metrological services: 2 books. Book 1 / M. Golubev. - 3rd ed., pererab. I DOP. - M.: publishing standards, 1990. - 528 p.

[2]The Bikulov, A. M. Calibration of measuring instruments pressure and temperature: textbook/ A. M. Bikulov. - Moscow: ASMS, 2005. - 450 p.

[3]Parfenyeva I. E., Aksenov A. N. Analysis of the validity of a verification of means of measurement-pressure // Technical science - from theory to practice: collection of articles in mater. XIX international.scientific.-prakt. Conf. - Novosibirsk: Sibak, 2013.