Study of the membrane capacitive sensor Baratron from the composition of the state primary special standard GET 49-2016 to the state primary special standard of the pressure unit for the pressure difference GET 95-2020

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Abstract. This article is dedicated to the investigation of the membrane capacitive sensor Baratron on the state primary special standards GET 95-2020 and GET 49-2016. The article describes the stages and some results of the work.

The state primary special standard of the pressure unit for the pressure difference GET 95-2020 leads the state calibration scheme for measuring devices for the pressure difference up to $1 \cdot 10^5$ Pa. GET 95 was developed in 1975. Improved and researched from 2017 to 2019 at D. I. Mendeleyev Institute for Metrology VNIIM.

The standard implements the method of independent reproduction of the pressure difference with micromanometers and pressure balances of various types with overlapping measuring ranges. These are micromanometers MVK, MKSh and two MGP pressure balances for different pressure ranges. This also includes devices for generating and maintaining pressure.

From 2009 to 2011 the standard participated in important comparisons of national standards for the pressure unit in the range of 100-5000 Pa (COOMET.M.P-K14). The comparison covered 4 countries: Germany (was a pilot project), Russia, the Czech Republic, Lithuania. Russia currently has 3 SMC lines in the differential pressure range. The printing unit is transferred from the national primary special standard of Russia to the national standards of Kazakhstan and Belarus.

The state offers solutions to problems in priority areas of the development of science and technology, such as the creation of transport, aviation and space systems, energy and energy conservation, special equipment, technologies for creating new generations of rocket and space, aviation and marine equipment, and many others [1–4].

The general view of the standard GET 95 is shown in figure 1. The state primary special standard of the pressure unit for the range of absolute pressures GET 49-2016 leads the state calibration scheme for absolute pressure measuring devices in the range from $1 \cdot 10^{-6}$ to $1 \cdot 10^3$ Pa.

The standard is a reference complex based on membrane-capacitive converters and a vacuum reduction unit (VREU). A reference complex based on membrane-capacitive vacuum gauges, the range of reproducible pressure values ranges from $1 \cdot 10^{-3}$ to $1 \cdot 10^3$ Pa. The standard provides for the reproduction, storage and transmission of a Pascal pressure unit in the range of low absolute pressures in the range of $1 \cdot 10^{-6}$ to $1 \cdot 10^3$ Pa on working standards and measuring devices used in the Russian
Federation, according to the «State special standard and state calibration scheme for absolute pressure measuring devices in the range from $1 \cdot 10^{-8}$ to $1 \cdot 10^3$ Pa». The reference complex based on VREU has a reproducible pressure range from $1 \cdot 10^{-6}$ to $1 \cdot 10^{-2}$ Pa. In addition, GET 49-2016 contains special devices for generating and maintaining pressure.

The standard guarantees the operational safety of technical objects that were created in high-tech focus areas of science and technology; Development of new methods for the diagnosis of structural materials, such as hydrogen diagnosis of materials, analysis of the content of impurities in various gases in materials and products; Creation of new modern domestic digital vacuum gauges with extended measuring range as part of the import substitution program; Integration of the Russian Federation into the world economy, expansion of the measuring capacities of the Russian Federation in the field of pressure measurements; Increasing the competitiveness of the products manufactured by the Russian Federation’s industry on the world market [5–7].

In order to ensure the equivalence of the measurement results of the GET 49-2016 and GET 95-2020 standards at the national unit in D. I. Mendeleev Institute for Metrology VNIIM, comparisons of these standards are made.

A membrane capacitive pressure sensor Baratron 698 serves as a reference standard and the examined MI. This is a differential device that can work in the pressure difference range - up to 1 kPa, as well as in the range of vacuum measurements.

The functional principle of the sensor is based on the use of the relationship between the measured pressure and the elastic deformation of the sensitive element. A flat metal membrane is used as a sensitive element in the sensors, which divides the stainless steel chamber into two parts: a reference and a measuring chamber. On the carrier side, electrodes are connected to the membrane via insulators, which together with the membrane form two variable capacitances that are contained in the arms of the measuring bridge. The measured pressure is applied to the other side of the diaphragm, causing the diaphragm to deform, which leads to a change in capacitance and an imbalance in the measuring bridge. Electrical signal of the imbalance of the measuring bridge, proportional to the measured pressure.
In the case of sensors, when measuring the pressure difference, the atmospheric pressure or the reference pressure with the electrodes, the reference chamber enters, which enables a direct measurement of the pressure difference with the required error.

The general view of the membrane capacitive sensor Baratron from the composition GET 49-2016 and the micromanometer MKSh from the standard GET 95-2020 is shown in figure 2.

![Figure 2. General view of the sensor of the membrane-capacitive Baratron from the GET 49-2016 composition and the micromanometer of the MKSh from the GET 95-2020 standard.](image)

The results of studies of the Baratron pressure sensor on the GET 95-2020 standard are shown in table 1.

The work carried out confirms the high metrological level of state standards and the willingness to carry out international comparisons with an expanded country contingent.

The results obtained from studies of the Baratron pressure sensor confirmed the equivalence of the metrological properties of the GET 95-2020 and GET 49-2016 standard, as well as their values indicated in the operational documentation for the standards.
Table 1. Results of studies of the Baratron sensor.

| №  | Indications of MKSh, mm H₂O | Pressure sensor readings Baratron, mm H₂O | Absolute error, mm H₂O | Reduced error, % | Ambient temperature, °C | Water temperature MKSh, °C |
|----|-----------------------------|-----------------------------------------|------------------------|-----------------|----------------------|------------------------|
| 1  | 0                           | 0.000                                   | 0.000                  | -               | 21.3                 | 21.3                   |
| 2  | 1                           | 1.001                                   | 0.001                  | 0.100           | 21.3                 | 21.3                   |
| 3  | 2                           | 2.001                                   | 0.001                  | 0.050           | 21.3                 | 21.3                   |
| 4  | 3                           | 3.002                                   | 0.002                  | 0.067           | 21.3                 | 21.4                   |
| 5  | 4                           | 4.003                                   | 0.003                  | 0.075           | 21.4                 | 21.4                   |
| 6  | 5                           | 5.004                                   | 0.004                  | 0.080           | 21.4                 | 21.5                   |
| 7  | 8                           | 8.006                                   | 0.006                  | 0.075           | 21.4                 | 21.5                   |
| 8  | 10                          | 10.008                                  | 0.008                  | 0.080           | 21.4                 | 21.5                   |
| 9  | 15                          | 15.011                                  | 0.011                  | 0.073           | 21.5                 | 21.5                   |
| 10 | 20                          | 20.015                                  | 0.015                  | 0.075           | 21.5                 | 21.5                   |
| 11 | 30                          | 30.027                                  | 0.027                  | 0.090           | 21.5                 | 21.5                   |
| 12 | 50                          | 50.031                                  | 0.031                  | 0.062           | 21.5                 | 21.5                   |
| 13 | 70                          | 70.065                                  | 0.065                  | 0.093           | 21.5                 | 21.6                   |
| 14 | 90                          | 90.051                                  | 0.051                  | 0.057           | 21.5                 | 21.6                   |
| 15 | 100                         | 100.039                                 | 0.039                  | 0.039           | 21.5                 | 21.6                   |

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