Intensive leak standards for helium leak detection

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Abstract. The article discusses the main reasons for the demand for gas leak standards with a flow range of $5 \times 10^{-7}$ to $5 \times 10^{-4}$ Pa\cdot m$^3$/s, for helium leak detection. The high flow Leak Standards Vactron VKT are presented.

Leak detection by gas methods is carried out in order to check the tightness of the test item according to the standards specified in the design documentation. In Russia the check is mainly carried out on certified test devices according to GOST R 8.568-2017 "Certification of test equipment. Basic provisions". For tests for the conformity assessment of defense products, certification is carried out taking into account the requirements of the document GOST RV 0008 002 2013 "Certification of test devices that are used in the conformity assessment of defense products. Organization and procedure".

The most important measuring devices that are part of the leak test stands are mass spectrometric helium leak detectors, leak standards and vacuum gauges.

For testing of products with technical regulations, in the manufacture of products supplied under state, there are mandatory requirements have been specified, measuring devices of approved types must be used, copies of measuring devices must be verified. For tests in areas where no special requirements are made, calibrated measuring devices may be used [1].

On the Russian market there are currently 9 types of mass-produced mass spectrometric helium leak detectors, including a mass spectrometric helium leak detector Ulvac Heliot and NPF Progress MS-4. There are a variety of vacuum gauges on the market for monitoring pressures around 0,01 Pa, including Russian production. The main problem for leakage control is the choice of gas reference leaks.

The following types of leak standards, listed in table 1, are currently approved as measuring devices and entered in the Federal Information Fund to ensure uniformity of measurements – the State Register of the measuring devices).

| №  | Name of MI | Flow range, Pa\cdot m$^3$/s | Relative error, % |
|----|------------|----------------------------|-------------------|
| 1. | Gelit 1    | $7 \times 10^{-10} - 2 \times 10^{-8}$ | ±15               |
| 2. | Gelit 2    | $3 \times 10^{-11} - 7 \times 10^{-10}$ | ±20               |
| 3. | 10xxxx     | $1 \times 10^{-9} - 9 \times 10^{-6}$ | ±15               |
| 4. | Fx4xxx     | $1 \times 10^{-10} - 3 \times 10^{-5}$ | ±15               |
The table shows that the most common leak standards in Russia (helium leaks) Gelit 1 and Gelit 2 have a rather narrow range of flow reproduction, another helium leaks have a larger flow, but their main disadvantages are delivery times and costs.

With leak standards you can set the mass spectrometric helium leak detector so it receives the correct quantitative leakage flow under certain test conditions. The basic equation used in leak detectors to calculate the leakage flow \( Q \) value has the form (1).

\[
Q = Q_{\text{ref}} \frac{\alpha_{\text{izm}} - \alpha_0}{\alpha_{\text{izm,ref}} - \alpha_0},
\]

where \( Q_{\text{ref}} \) is the value of the flow of the leak standards installed in the leak detector or in the vacuum system, specified in the certificate of verification (calibration);

\( \alpha_{\text{izm}} \) is the value of the sample gas flow from the vacuum system or from the controlled object, measured by the leak detector in real time;

\( \alpha_{\text{izm,ref}} \) is the value of the sample gas flow from the test leak installed in the leak detector (or in the vacuum system), measured by the leak detector;

\( \alpha_0 \) is background signal level [2].

As can be seen from the formula, leak standards contribute significantly to the accuracy and reliability of the results obtained in the tests. By using leak standards, it can be ensured that the test gas flow is precisely recorded by the leak detector and that the worst and most distant fault of the test object can be simulated. For this reason, when testing large-volume test items, the leak detector should be adjusted with the flow rate measurements located at the furthest part of the leak standards in order to determine the actual sensitivity of the leak detector.

The most widespread normative document recently used in Russia for leakage control is GOST R 50.05.01-2018 "Conformity assessment system in the field of atomic energy use. Conformity assessment in the form of control. Uniform techniques. Leak test using gas and liquid methods". According to this normative document, five tightness classes of the control objects are defined, as indicated in table 2.

| Tightness class | Ranges of permissible values of test gas flows through leakage of the test object at operating pressure, Pa·m\(^3\)/s |
|-----------------|--------------------------------------------------------------------------------------------------|
| I               | from \( 5 \times 10^{-11} \) to \( 5 \times 10^{-10} \) inclusive                                  |
| II              | from \( 5 \times 10^{-10} \) to \( 5 \times 10^{-9} \) inclusive                                  |
| III             | from \( 5 \times 10^{-9} \) to \( 5 \times 10^{-7} \) inclusive                                  |
| IV              | from \( 5 \times 10^{-7} \) to \( 5 \times 10^{-6} \) inclusive                                  |
| V               | from \( 5 \times 10^{-6} \) to \( 5 \times 10^{-4} \) inclusive                                  |

According to GOST R 50.05.01-2018, leak standards for setting and evaluating the parameters of the leakage control procedure must show a flow of the test substance in the range of the tightness standards according to a certain tightness class of the object. Therefore, the composition of the leak test stand should include the required number of leak standards in order to be able to control the required number of leakage classes.

To ensure the tightness control for tightness classes IV and V, there are currently no test leaks from Russian production of an approved measuring device type.

In 2019 the company Vactron (Saint-Petersburg), by order of D. I. Mendeleyev Institute for Metrology VNIIM, developed and manufactured new gas leak standards Vactron-VKT with the possibility of filling with different test gases.

Vactron-VKT test leaks are sealed metal cylinders with a DN25KF standard flange on one side for connecting the leak to the vacuum system to be tested. The appearance of the Vactron-VKT test leaks
is shown in figures 1 and 2 also shows the structure of a leakage test stand with a Vactron-VKT calibration leak before testing using the probe method.

![Figure 1. The appearance of the test leaks of the Vactron-VKT.](image1)

![Figure 2. The process of setting up the test leak stand using the Vactron-VKT control leak before testing by the probe method.](image2)

The walls of the cylinder form a closed volume filled with test gas. During operation, a test gas flows through the permeable element [3]. All metal elements of the calibration leak are made of stainless steel. Calibration leaks are filled and sealed by the manufacturer up to the set test gas pressure. The technical properties of the Vactron-VKT test leaks are shown in table 3.

### Table 3. Technical characteristics of the Vactron-VKT test leaks.

| Parameter                                                                 | Value                                      |
|---------------------------------------------------------------------------|--------------------------------------------|
| The range of values of the reproducible sample gas flow at a temperature of (27±0.5) °C, Pa·m³/s (the sample gas flow is set during production in accordance with the request) | 1·10⁻⁷ – 1·10⁻⁴                           |
| Temperature correction to the flow, deg¹                                    | 2 %                                        |
| Limits of the permissible relative error of stream reproduction, %          | ±30                                        |
| Operating temperature, °C                                                   | 10 – 40                                    |
| Cylinder pressure range, MPa                                                | 0,1 – 1                                    |
| Possibility of filling with gases                                           | helium, nitrogen (refueling with other gases is possible) |
| Flange                                                                     | DN25KF (other types of flanges are possible) |
| Weight not more than, kg                                                   | 3                                          |

In order to provide with test leaks for all tightness classes, Vactron supplies a standard leak kit Vactron-KGT that contains three standard leaks: Gelit-1, Gelit-2 and intensive flow Vactron-VKT leak.
The set of helium leaks KGT includes a valve for closing the test leaks while the leak detector is being set up, as well as an adapter that enables the test leaks to be hermetically connected to the monitored objects. The appearance of the Vactron-KGT standard leaks kit is shown in figure 3.

![Vactron-KGT standard leaks kit](image)

**Figure 3.** Vactron-KGT standard leaks kit.

From the amount of helium leaks, the specialist who carries out work on the leakage control must, before the test, select a standard leak for the installation of the leak detector that complies with the leakage standard - i.e. the standard leaks, which separates the sealed from the unusable product during the control process.

Vactron-VKT control leaks can be connected to vacuum or flow to the atmosphere. The flow rate can be adjusted by on the pressure of the sample gas in the cylinder. It is done by authorized personnel only to save the measurement characteristics. Figure 4 graphically shows the dependence of the Vactron-VKT test leak flow on the test gas filling pressure (here helium).

![Graph of the dependence of the flow of the test leak of the Vactron-VKT on the pressure of filling with helium](image)

**Figure 4.** Graph of the dependence of the flow of the test leak of the Vactron-VKT on the pressure of filling with helium.

Test leaks Vactron-VKT are currently not included as measuring devices in the Federal Information Fund to ensure the uniformity of measurements (State Register of the MI). The company has repeatedly issued D. I. Mendeleyev Institute for Metrology VNIIM for the calibration of VKT test leaks to determine the value of the measuring gas flow.

The calibration was carried out on the secondary (working) standard of a gas flow unit in a vacuum in the range of $1\cdot10^{-12}$ to $1\,\text{Pa}\cdot\text{m}^3/\text{s}$ (GVET 49-2-2006). During calibration, the metrological properties did not exceed the values specified by the manufacturer.

In the future, it is assumed that tests will be carried out to allow the type of Vactron-VKT test leak measuring devices. The approval of the test leak measuring device type Vactron-VKT enables the solution of the problem of equipping booths for leakage control with household measuring devices.
Vactron-VKT standard reference leaks provide a reliable and stable source of low gas flows into the vacuum system. They can be widely used for flow measurement and for supplying a controlled flow or quantity of gas to a process.

References
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[2] Fomin D M 2020 Nanoindustry 13 2 78–83
[3] Vinogradov M L et al. 2015 Vakuum in Forschung und Praxis 27 3 26–9