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**Environmental testing - Part 2: Test methods - Text Q:
Sealing**

环境试验 第2部分：试验方法 试验Q：密封

(IEC 60068-2-17:1994, Basic environmental testing procedures - Part 2:
Tests - Test Q: Sealing, IDT)

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Environmental testing - Part 2: Test methods - Text Q: Sealing

1 Scope

This part of GB/T 2423 specifies various sealing performance test methods. Test Qa and Qc are rough inspections, to observe the bubbles emerging from the leak. Test Qd is to observe the leakage of liquid, under heating conditions. Test Qy is to make the gas pass through the leak and enter the test box, under reduced pressure, then measure the performance change of the test box. Test Qk, Qm is to use tracer gas to detect small leaks. Test Qf, Ql is to make liquid enter it through the leak, under pressurized conditions, then measure its performance changes.

This Part is suitable for testing the sealing performance of various electrical and electronic products. It is also suitable for testing the sealing performance of other sealing parts.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 2421.1-2008 Environmental testing for electric and electronic products - General and guidance (IEC 60068-1:1998, IDT)

GB 4208-2008 Degrees of protection provided by enclosure (IP code) (IEC 60529:2001, IDT)

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

Leak rate

Depending on the selected method, this test can be used to test the leak rate, which is more than $100 \text{ Pa} \cdot \text{cm}^3/\text{s}$, $10 \text{ Pa} \cdot \text{cm}^3/\text{s}$ or $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$ ($10^{-3} \text{ bar} \cdot \text{cm}^3/\text{s}$, $10^{-4} \text{ bar} \cdot \text{cm}^3/\text{s}$ or $10^{-5} \text{ bar} \cdot \text{cm}^3/\text{s}$). Test method 1 or 3 is only applicable to test samples, which have all the reduced pressure or increased pressure, as required to resist impregnation, without deformation or permanent physical damage (see B.1, B.2, B.3).

Test method 2 is applicable to test samples, which are subjected to a significant pressure difference due to heat, when working at the highest ambient temperature.

5.3 Test overview

5.3.1 Test summary

The test sample is immersed in a suitable liquid. Under controlled conditions, by observing the bubbles released on the surface of the test sample, check the gross leaks (see B.5).

Use one of the following test methods, to generate positive pressure inside the test sample.

5.3.2 Test method 1

The test is carried out in a vacuum, thereby increasing the pressure difference between the two sides of the test sample's seal.

5.3.3 Test method 2

The test sample is immersed in the test liquid, which is maintained at a high temperature (see B.10).

5.3.4 Test method 3

After immersing in a liquid, which has a boiling point lower than the test temperature, the sample is then immersed in the test liquid.

5.4 Test method 1

5.4.1 The test box, which has the liquid tank as required for this test, shall have the ability to pump a vacuum; the tank shall contain enough liquid, to immerse the uppermost end of the shell or seal of the sample under test, to a depth of more than 10 mm. The temperature of the test liquid (see B.8) shall be maintained between 15°C and 35°C . Before the vacuum is broken, the tank shall have the ability to drain or remove the test sample from the liquid.

5.4.2 The test sample is immersed in the test liquid, with the sealing surface facing upwards. Then the air pressure in the test box is reduced to 1 kPa OR

other values specified in the relevant specifications, within 1 min. If no failure is observed (see 5.4.4), then maintain this air pressure for a few minutes OR other duration, which is specified by the relevant specifications (see B.9).

5.4.3 Test samples, which have more than one sealing surface, shall be tested in accordance with 5.4.2, by making each sealing surface in the upward position (see B.4).

5.4.4 The failure criterion of this test is usually that, at any time during the duration of the test, there are obvious continuous bubbles, two or more large bubbles, or attached bubbles that gradually increase in volume (see B.6 and B.7).

5.5 Test method 2

5.5.1 The test liquid tank shall be filled with enough liquid, so that the uppermost end of the shell or seal of the sample under test, is immersed below the liquid, to a depth of more than 10 mm.

5.5.2 The temperature of the liquid shall be kept at 1 °C ~ 5 °C above the maximum working temperature of the sample to be tested OR the temperature specified in the relevant specifications.

5.5.3 The test sample at 15 °C ~ 35 °C is immersed in the test liquid, with its sealing surface up (see B.11). The immersion time is not less than 10 min OR specified by relevant specifications (see B.3).

5.5.4 Test samples, which have more than one sealing surfaces, shall be tested in accordance with 5.5.3, with each sealing surface in the upward position (see B.4).

5.5.5 The failure criterion of this test is usually that, at any time during the duration of the test, there are obvious continuous bubbles, two or more large bubbles or attached bubbles that gradually increase in volume (see B.6 and B.7).

5.6 Test method 3

5.6.1 Test summary

The method consists of two steps.

5.6.2 Step 1

Step 1 shall be carried out at room temperature.

Seal the test sample in a vacuum/pressurized container. Reduce the pressure to 100 Pa AND keep it for 1 h. Then fill the container with liquid (see B.12, B.13),

Note: This test also applies to test samples, where the filler is solid at room temperature, but liquid at the test temperature.

6.2 Scope

This test can be used to test the test sample, which is equivalent to an air leak rate greater than $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$. The sensitivity of this test method depends on the kinematic viscosity of the liquid, at the test temperature AND the leak detection technology used.

6.3 Test overview

This test is used to test the test sample, which may leak, when the temperature is slightly higher than the maximum working temperature of the test sample.

6.4 Severity level

The severity level is determined by the time, that it is kept at the test temperature. The relevant specifications shall select the applicable severity level, from the following time:

- 10 min;
- 1 h;
- 4 h;
- 24 h;
- 48 h.

6.5 Pretreatment

The test sample shall be cleaned (remove oil stains), so that the liquid leakage is clearly distinguished from other substances.

6.6 Initial inspection

Not required.

6.7 Condition test

6.7.1 Place the test sample in an air-circulating drying box. The temperature of the box is increased, until the surface temperature of the test sample is $1^\circ\text{C} \sim 5^\circ\text{C}$ above the maximum working environment temperature. The test sample shall be placed in a state, where leakage is most likely to be exposed.

6.7.2 The test sample shall be kept at the above temperature for the time, which is specified by the severity level, THEN taken out of the box.

6.7.3 Test samples, which have more than one sealing surfaces, shall be tested according to 6.7.1 and 6.7.2, with each sealing surface in the downward position in turn.

6.8 Final inspection

Check the leakage of the liquid with naked eyes. If there are no other provisions in the relevant specifications, the test sample shall have no leakage.

Relevant specifications shall specify inspection methods (see C.2).

6.9 Detailed rules to be given in relevant specifications

When this test is included in the relevant specifications, specific provisions shall be made for the following items:

- a) Test temperature (see 6.7.1);
- b) The duration of the condition test (see 6.7.2);
- c) Method of checking leakage (see 6.8).

7 Test Qf: water immersion

7.1 Purpose

Determine the water tightness of components, equipment or other products, which are immersed in water, under the specified pressure and time.

7.2 Test overview

The test sample is immersed in a specified depth, in a water container, OR placed in a high-pressure water tank; the specified pressure is applied to the test sample. After the condition test, check the water infiltrated into the test sample AND check its possible performance changes.

7.3 Initial inspection

According to relevant specifications, carry out the electrical and mechanical performance measurement and appearance inspection of test samples. All sealing parts shall be inspected, to make sure that their installation is correct.

7.4 Pretreatment

Pre-treat the test sample and the sealed part, according to relevant specifications.

7.5 Condition test

dried test sample into a box, which contains pressurized helium mixed gas, for pressurization, so that helium can penetrate into the test sample cavity. After the given time, put the test sample into a test box again. Then evacuate the test box. Connect it with the mass spectrometer. Pump the helium, which is leaked from the test sample, into the mass spectrometer. Measure the amount of leakage. The measured helium leak rate is converted into the equivalent standard leak rate, by calculation method, so as to compare the test samples of the same volume, which are tested under different test conditions. If the time constant $\theta = P_0V/L$ (see D.1) of the test sample is compared, THEN, the comparison, between test samples of different volumes, is still valid.

8.3.2 Test method 2 is the same as method 1, except that pressurized immersion is omitted. The test shall usually be completed, within 30 minutes after packaging. For large samples, it will take a longer time, depending on the cavity volume and package thickness (see E.7.2). For small samples, the test shall be carried out, immediately after packaging (see E.7.1, E.7.2).

For general sealing tests, such as sealing tests performed after other environmental tests, this method is not suitable.

8.3.3 The pressure for pressurization and testing shall be selected in such a way, that it is consistent with the maximum possible air pressure, that the test sample may withstand, without seal damage.

8.3.4 If gas leakage is not detected by this test, test Qc or an equivalent test shall also be performed, on the test sample.

8.3.5 Method 3 is to connect one side of the sample to the vacuum chamber, which is connected to the mass spectrometer. Then use a sealing cover, which is filled with helium, to cover the visible surface of the sample (Method a), OR use a thin helium spray gun to spray (Method b).

Method a: If there is a leak, the helium in the helium cover will enter the vacuum chamber; its size can be determined, according to the reading of the mass spectrometer (but the position cannot be determined).

Method b: When the helium gun passes through a sealing defect, the instrument can detect helium; it may determine the leak location and size, according to the reading of the mass spectrometer.

8.4 Qk test method 1 (applicable to test samples that are not filled with helium during the manufacturing process)

8.4.1 Severity level

The severity level is determined by the minimum time constant, which is required for use. The relevant specifications shall select the appropriate level

from Table 5. In the case where different severity levels shall be specified, the relevant specifications shall specify all relevant test parameters (see Appendix D).

8.4.2 Pretreatment

Remove the contamination on the test sample, which may mask leakage or adsorb helium, such as grease, fingerprints, flux, paint. After cleaning, the test samples shall be dried, to remove traces of solvents, capillary aggregates, etc. They may cover up existing leaks. The test shall be carried out on the test sample without any external attachments, which may trap helium.

Note: In order to optimize the pre-processing program, each technology used shall be studied in advance.

8.4.3 Initial inspection

Not required.

8.4.4 Test parameters

Table 5 gives the test parameters AND the acceptance limits of the allowed measured leak rate R , for the internal cavity volume of different test samples, based on the severity levels and test methods, which are selected according to the relevant standards.

8.4.5 Condition test

The test sample shall be placed in a closed test box.

When the maximum pressure, which is specified by the relevant specification, does not exceed 200 kPa (absolute value), the tester selects one of the following procedures:

- a) Reduce the pressure inside the box to an absolute value of about 0.1 kPa ~ 1 kPa.
- b) OR use helium to clean the test chamber (see E.3).

When the charging pressure, which is required by the relevant specifications, is stronger than 200 kPa, neither of the above two procedures is required.

Unless otherwise specified, the test chamber shall be filled with a mixed gas, which has a helium content of at least 95%; then pressurized according to the time and pressure, which are selected in Table 5. The pressure shall not be greater than the maximum pressure, which is specified by the relevant specifications, for this type of device (see E.8.4).

8.6 Test method 3 (applicable to samples installed on walls and flat plates)

8.6.1 Pretreatment

Clean the sample to remove all contaminants, such as grease fingerprints, flux, or paint, which can easily block the leak. After cleaning, put the sample in an oven, to dry to remove residual solvents, capillary condensate, etc., which will also block the leak.

8.6.2 Initial inspection

A valve is used to airtightly separate the chamber from the test port, to vacuum the chamber. When the pressure drops to low enough to allow the mass spectrometer to work normally, connect the chamber to the mass spectrometer.

Note the background signal of the mass spectrometer without helium injection.

Use a reference helium leak, to check whether the mass spectrometer is functioning properly.

8.6.3 Test

Put the sample on the test port. Open the isolation valve to vacuum. Check the vacuum degree, to keep the mass spectrometer working normally. Continue vacuuming, until the background signal stabilizes at a level, which is approximately consistent with the previously measured value.

Method a: Use a helium-filled flexible cover or plastic cover, to cover the outside of the sample; pay attention to the reading of mass spectrometer.

Method b: Use a small low-pressure helium gun, to sweep the entire surface of the sample; pay attention to the reading of mass spectrometer.

Note: If possible, the relevant specifications shall specify helium pressure (see E.14).

8.6.4 Final inspection

The measured leak rate R can be obtained, by comparing with the standard leak; the background signal shall be subtracted.

8.7 The detailed rules to be given in relevant specifications

When this test is included in the relevant specifications, the following items shall be specified:

- a) Test method (see 8.2, 8.3);

Test method 1

This test is suitable for any sample, which can withstand internal pre-pressurization; it can detect a leak rate, which is greater than $10^{-8} \text{ Pa} \cdot \text{m}^3/\text{s}$ ($10^{-7} \text{ bar} \cdot \text{cm}^3/\text{s}$).

10.3 Test overview

10.3.1 Overall method and positioning method

A test can determine the total leakage, BUT the number and location of the leakage cannot be given at the same time. Therefore, it is necessary to distinguish the "overall method" from the "positioning method". The overall method can measure the total amount of leakage; the positioning method can determine the location of a single leak, when repairs are required.

Example: Cumulative test is an "overall method"; probe test is a positioning method. Another possibility is an "intermediate method", that accumulates the measured leak rate from one part of the sample (overall method); then applies this method to each part of the sample.

10.3.2 Test method 1: Cumulative test

A tracer gas is used to pre-pressurize the internal cavity of the sample to be tested; the leakage rate will stabilize after a specified time. Use a sealing cover, to cover the entire sample (or part of its surface). During the test, the gas leaking from any defect is collected in the sealing cover; then the collected gas is measured AND the leakage rate is calculated.

10.3.3 Test method 2: Probe test

A tracer gas is used to pre-pressurize the inner cavity of the sample to be tested. The leakage rate will stabilize, after a specified time. Bring the leak detector's probe close to the sample. Move it on its surface. If the tracer gas's concentration reaches the threshold of the leak detector, a signal is given, so that the leak location can be found.

Note: The probe test cannot detect the leak rate, BUT sometimes it can be estimated whether the specified leak rate is exceeded. In this case, it is necessary to know the threshold value and measurement conditions of the leak detector (environmental pollution conditions, probe moving speed, sample characteristics, etc.).

10.4 Pretreatment

Carefully seal each unused opening, to avoid any interference to the leakage rate measurement of the sample being tested. If an opening is to be used later, the seal, which is connected to the accessory, shall be tested.

The relevant specifications shall indicate any additional pretreatment.

Wash and dry the sample.

10.5 Condition test

10.5.1 Overview

The relevant specifications shall give:

- a) The method used (Test method 1 or method 2 or "intermediate method");
- b) Whether the sample is working; if not, its status (ON, OFF, ready, etc.).

10.5.2 Test method 1: Cumulative test

10.5.2.1 Procedure

- a) Pre-pressurize the sample; the relevant specifications shall give the test pressure. If the filled gas needs to be recovered, it shall make vacuum, before pressurizing;
- b) Relevant specifications shall provide waiting time (see G.1), to balance the leakage rate;
- c) Put on the cover, which determines the measurement volume; measure the concentration C_0 of the tracer gas, at the time t_0 ;
- d) After a certain period of time, which depends on the sensitivity (see G.2.1), measure the final concentration C_1 , at the time t_1 .

Note: The accumulative test can be performed with or without a meter. As long as the threshold is known, the method is to start from the starting concentration, in fact, from zero; insert the probe into the measurement volume at even intervals, until there is a signal.

10.5.2.2 Interpretation of results

A calibration curve can be used, to convert the meter reading into a concentration. The calibration curve shall be checked periodically. The sample's leak rate R can be calculated by formula (2):

$$R = 10^{-6} \times \frac{V_m (C_1 - C_0) p_e}{t_1 - t_0} \dots\dots\dots (2)$$

Where:

R - Leak rate, the unit is Pascal cubic meter per second ($\text{Pa} \cdot \text{m}^3/\text{s}$);

V_m - Measuring volume, the unit is cubic meter (m^3);

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