

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Environmental testing –
Part 2-17: Tests – Test Q: Sealing**

**Essais d'environnement –
Partie 2-17: Essais – Essai Q: Etanchéité**



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**Environmental testing –
Part 2-17: Tests – Test Q: Sealing**

**Essais d'environnement –
Partie 2-17: Essais – Essai Q: Etanchéité**

INTERNATIONAL
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ENVIRONMENTAL TESTING –

Part 2-17: Tests – Test Q: Sealing

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IEC 60068-2-17 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 1994. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) "Survey of sealing tests" has been deleted and the relevant content moved to a new Clause 4 "General";
- b) the Scope has been revised;
- c) the figures have been updated for clarification purposes;
- d) all non-SI units have been removed;
- e) the information to be given in the relevant specification has been revised.

The text of this International Standard is based on the following documents:

Draft	Report on voting
104/984/FDIS	104/1000/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

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- reconfirmed,
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- replaced by a revised edition, or
- amended.

ENVIRONMENTAL TESTING –

Part 2-17: Tests – Test Q: Sealing

1 Scope

This part of IEC 60068 deals with seal tests applicable to the external and internal detection in container sealing of gross leaks and fine leaks to determine the effectiveness of seals of specimens. For further tests to verify the ability of enclosures, covers and seals to maintain components and equipment in good working order, IEC 60068-2-18 can be helpful.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

leak rate

quantity of a dry gas at a given temperature that flows through a leak per unit of time and for a known difference of pressure across the leak

3.2

standard leak rate

leak rate under standard conditions of temperature and pressure difference of 25 °C and 10⁵ Pa

3.3

measured leak rate

R

leak rate of a given device as measured under specified conditions and employing a specified test gas

Note 1 to entry: Measured leak rates are often determined with helium employed as the test gas under a pressure difference of 10⁵ Pa at 25 °C. For the purpose of comparison with leak rates determined by other methods of testing, the leak rates should be converted to equivalent standard leak rates.

3.4

equivalent standard leak rate

L

standard leak rate of a given device with air as the test gas

Note 1 to entry: The equivalent standard leak rate is expressed in Pa · cm³/s.

3.5**time constant** θ

<of leak> time required for equalization of the partial pressure difference across a leak if the initial rate of change of that pressure difference were maintained

Note 1 to entry: For the purpose of Test Q, the time constant is equal to the quotient of the internal volume of the specimen and the equivalent standard leak rate.

3.6**gross leak**

any leak with an equivalent standard leak rate greater than $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$

3.7**fine leak**

any leak with an equivalent standard leak rate smaller than $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$

3.8**virtual leak**

semblance of a leak caused by slow release of absorbed, adsorbed or occluded gas

3.9**leak meter**

<in Test Qm> apparatus consisting of a hand probe for taking a sample of gas mixture and a meter providing a graduated display of the concentration of a predetermined type of gas in the sample

3.10**volume of measurement** V_m

<in Test Qm> volume contained between the gastight sheath collecting the leak and the specimen

3.11**leak detector**

<in Test Qm> apparatus consisting of a hand probe for taking a sample of gas mixture and a device sensitive to the presence of a predetermined type of gas and emitting a signal, either acoustic or visual, when the concentration of a predetermined type of gas reaches a pre-set threshold level

3.12**probing**

DEPRECATED: sniffing

<in Test Qm> action of slowly moving the probe of a leak detector along a specimen to locate the leaks

4 General

Test Q: Sealing includes several tests which use different conditioning procedures appropriate for different applications.

NOTE Other tests of this category are rain and water tests which are described in IEC 60068-2-18.

The family tree of all sealing tests is shown in Figure 1.

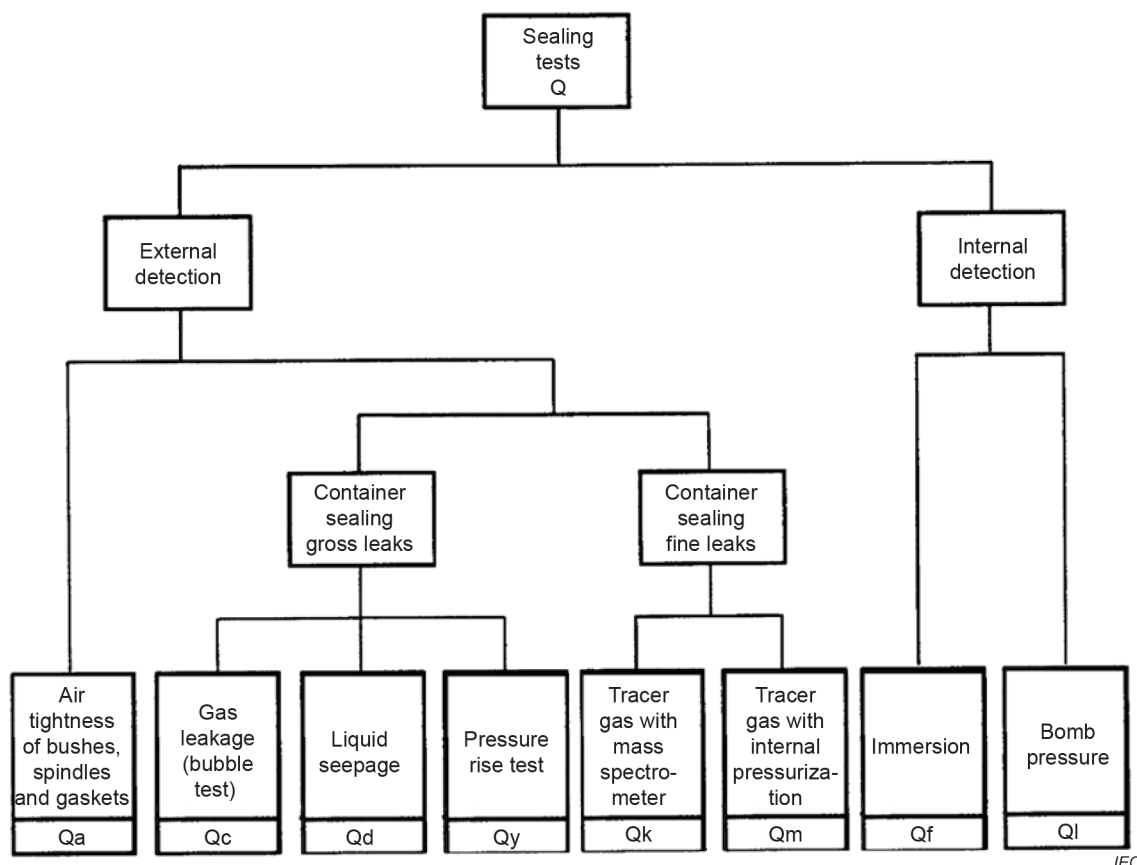


Figure 1 – Family tree of all sealing tests

Test Q can be subdivided in the following two subgroups, distinguished by their detection methods:

- internal detection, which measures changes of electrical characteristics produced by the test medium (liquid or gas) introduced into the specimens through the leak;
- external detection, whereby the escape of the test medium through the leak is observed.

The two tests for internal detection Qf and Ql are very similar. They are very effective for certain components, for example plastic-foil capacitors; they are not recommended, however, for components in which electrical changes become effective only after a long time (for instance, after the test is terminated).

The tests for external detection are further subdivided according to their application. Test Qa is a bubble test which is used to determine the airtightness of bushes, spindles and gaskets. The other tests, Qc, Qd, Qk and Qm, are used to determine leaks in containers (metallic cases, housings, etc.).

Test Qc is a bubble test again including three methods with different sensitivities (leaks not less than $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$). Test Qd is a liquid seepage test which may be applied to specimens filled during manufacture with a liquid or a product becoming liquid at the test temperature.

Tests Qk and Qm are the most sensitive of this series. Their sensitivity ranges from $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$ to about $10^{-6} \text{ Pa} \cdot \text{cm}^3/\text{s}$.

5 Test Qa: Sealing of bushes, spindles and gaskets

5.1 Object

To determine the effectiveness of seals of bushes, spindles and similar features. For this test, two types of seals shall be considered:

- Type A: 100 kPa (10 N/cm²) to 110 kPa (11 N/cm²) in the direction specified in the relevant specification.
- Type B: 100 kPa (10 N/cm²) to 110 kPa (11 N/cm²) in each direction.

5.2 Scope of Test Qa

This test can be used for the detection of gross leaks.

5.3 General description of the test

The specimen is mounted on the lid at a pressurized test chamber which is submerged in a liquid. If the specimen leaks, the air escaping is collected. The amount of air collected per time is a measure of the air leak. A suitable test apparatus is described in Annex A.

5.4 Initial measurements

There are no initial measurements required for Test Qa.

5.5 Conditioning

An air pressure difference, as specified below, shall be applied across each seal or simultaneously across a group of seals forming an assembly, if not specified otherwise.

- Type A: 100 kPa (10 N/cm²) to 110 kPa (11 N/cm²) in the direction specified in the relevant specification.
- Type B: 100 kPa (10 N/cm²) to 110 kPa (11 N/cm²) in each direction.

Where a higher pressure is required, it shall be 340 kPa (34 N/cm²) to 360 kPa (36 N/cm²).

NOTE It is possible that the test apparatus described in Annex A will not be suitable for these higher pressures.

Type B seals shall be tested both in a static condition and while being mechanically operated as required by the relevant specification.

5.6 Final measurements

The rate of leak shall be measured. The limit shall be specified in the relevant specification.

5.7 Information to be given in the relevant specification

When Test Qa is included in the relevant specification, the following details shall be given as far as they are applicable:

	Subclause
a) Requirements for pressure	5.5
b) Direction of application of pressure difference	5.5
c) Mechanical operation during conditioning	5.5
d) Requirements for leak rate	5.6

6 Test Qc: Container sealing, gas leak

6.1 Object

To determine the effectiveness of seals of specimens having an included gas-filled space (e.g. specimens not completely filled with impregnant).

6.2 Scope of Test Qc

This test can be used for the detection of leak rates greater than (100, 10 or 1) Pa · cm³/s according to the method chosen.

Test Methods 1 and 3 are applicable only to specimens that are able to withstand full decompression and the compression necessary for the impregnation without suffering distortion or permanent physical damage.

Test Method 2 is applicable to all specimens subject to a significant thermally generated pressure differential being achieved at the maximum ambient temperature of operation of the specimen.

Guidance on Test Qc is given in Annex B.

6.3 General description of the test

The detection of gross leaks is achieved by submerging the test specimen in a suitable liquid, under controlled conditions and by observing bubbles emanating from the specimen surface.

A positive internal pressure within the test specimen is generated by one of the following test methods:

a) Test Method 1

Conducting the test in a vacuum environment, thereby increasing the pressure differential across the seals of the test specimen.

b) Test Method 2

Through immersion in a test liquid maintained at an elevated temperature.

c) Test Method 3

Through immersion in a test liquid, following impregnation with another liquid having a boiling point below the test temperature.

6.4 Test Method 1

The test chamber containing the bath required for this test shall be capable of being evacuated, and the bath shall contain sufficient liquid to enable the specimens to be immersed so that the uppermost surface of the specimen enclosure or seal to be tested is at a depth of not less than 10 mm below the surface. The test liquid shall be maintained at a temperature between 15 °C and 35 °C. The bath should be capable of being drained of the liquid or having the specimen removed from the liquid before breaking the vacuum.

Specimens shall be immersed in the test liquid with their seals uppermost. The pressure within the test chamber shall then be reduced within 1 min to a value of 1 kPa or as otherwise specified in the relevant specification. If no failure has been observed this pressure shall be maintained for another minute or any duration specified in the relevant specification.

Specimens possessing seals on more than one surface shall be tested with each surface in the uppermost position.

Failure criteria for this test shall be the observance of a definite stream of bubbles, or more than two large bubbles, or an attached bubble that grows at any time during the test.

6.5 Test Method 2

The bath required for this test shall contain sufficient liquid to enable the test specimens to be completely immersed to a depth of not less than 10 mm above the uppermost part of the enclosure or seal to be tested.

The liquid shall be maintained at a temperature of 1 K to 5 K above the maximum ambient temperature of operation for the specimen under test or at the temperature required in the relevant specification.

The specimens, which shall be at a temperature between 15 °C and 35 °C, shall be immersed in the test liquid with their seals uppermost for a period of at least 10 min, or as specified in the relevant specification.

Specimens possessing seals on more than one surface shall be tested with each surface in the uppermost position.

Failure criteria for this test shall be the observance of a definite stream of bubbles, or more than two large bubbles, or an attached bubble that grows at any time during the test.

6.6 Test Method 3

Test Method 3 consists of two steps.

a) Step 1

Step 1 shall be performed at ambient temperature.

The specimens shall be enclosed in a vacuum/pressure vessel and the pressure reduced to about 100 Pa for 1 h. After that time, and without breaking the vacuum, an impregnation liquid shall be drawn into the vessel until the specimens are covered by it.

The specimens shall then be pressurized under conditions as shown in Table 1.

Table 1 – Test conditions for Test Method 3, Step 1

Internal cavity volume	Minimum pressure (absolute)	Minimum duration
< 0,1 cm ³	600 kPa	1 h
> 0,1 cm ³	300 kPa	2 h

At the end of this impregnation time, the pressure shall be removed. The specimens shall be removed from the liquid and allowed to dry in air at ambient temperature for (3 ± 1) min or another duration specified in the relevant specification before performing Step 2.

b) Step 2

Test Method 2 shall apply, using a test temperature of (125 ± 5) °C, if not specified otherwise. The specimen shall be observed from the instant of immersion until 30 s after immersion, if not specified otherwise.

WARNING – The use of Test Method 3 can bear the risk of explosion, when a large specimen is likely to be filled with the impregnation liquid, that tends to vaporize rapidly during Step 2.

WARNING – The impregnation liquid can form toxic gases when boiled dry. Any direct contact with heating elements shall be prevented.

6.7 Information to be given in the relevant specification

When Test Qc is included in a relevant specification, the following details shall be given, as far as they are applicable:

	Clause or subclause
a) Test method	6.3, 6.4, 6.5, 6.6
b) Recommended liquid(s)	Annex B
c) Test Method 1: pressure and time, if different from 6.4	6.4
d) Test Method 2: liquid temperature, if different from 6.5	6.5
e) Test Method 2: immersion duration, if different from 6.5	6.5
f) Drying time if different from 3 min	6.6
g) Test Method 3: Step 2 temperature	6.6 b)

7 Test Qd: Container sealing, seepage of filling liquid

7.1 Object

To determine the effectiveness of seals of specimens filled with liquid. This test can also be used for specimens having a filling which is solid at room temperature, but which is liquid at the testing temperature.

7.2 Scope of Test Qd

This test can be used for the detection of leak rates corresponding to an air leak rate greater than about $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$. The sensitivity of the method depends on the kinematic viscosity of the liquid at testing temperature and the technique employed to detect seepage.

Guidance on Test Qd is given in Annex C.

7.3 General description of the test

The specimen is examined for seepage of liquid likely to occur when it is brought up to a temperature slightly higher than its maximum ambient temperature of operation.

7.4 Severities

A severity is defined as the period of time at which the specimen is maintained at the testing temperature. The relevant specification shall state the applicable severity chosen from the following list:

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

7.5 Preconditioning

The specimen shall be so cleaned (degreased) that possible seepage of liquid is clearly contrasted with all other materials.

7.6 Initial measurements

There are no initial measurements required for Test Qd.

7.7 Conditioning

The specimens shall be placed in an air circulating oven, in which the air is heated until the temperature of the surface of the specimens is 1 K to 5 K above its maximum ambient temperature of operation. The specimens should occupy an attitude most favourable to reveal a leak.

The specimens shall be maintained at this temperature for a period of time according to the specified severity and shall then be removed from the oven.

Specimens having seals on more than one face shall be tested with each such face in the downward position in turn.

7.8 Final measurements

The specimens shall be visually inspected for seepage of liquid. There shall be no seepage, if not specified otherwise.

The relevant specification shall specify the method of detection.

7.9 Information to be given in the relevant specification

When Test Qd is included in a relevant specification, the following details shall be given as far as they are applicable:

	Subclause
a) Test temperature	7.7
b) Duration of conditioning	7.7
c) Method of detecting seepage	7.8

8 Test Qf: Immersion

8.1 Object

To determine the watertightness of components or equipment or other articles when subjected to immersion under stated conditions of pressure and time.

8.2 General description of the test

The specimen is submitted to a specified pressure by immersion in a water tank at a specified depth or in a high-pressure water chamber. After conditioning, the specimen is examined for penetrated water and checked for possible changes of characteristics.

8.3 Initial measurements

The specimens shall be visually inspected and electrically and mechanically checked as required by the relevant specification. All sealing features shall be checked to ascertain that they have been correctly mounted.

8.4 Preconditioning

Preconditioning of the specimens and seals should be carried out where specified by the relevant specification.

8.5 Conditioning

The specimens shall be placed in the position as specified in the relevant specification and shall be completely immersed in a water tank or high-pressure water chamber. Detensioned water shall be used, if not specified otherwise. This can be achieved by adding a commercially available wetting agent to the water.

The specimens shall be subjected to one of the head-of-water values or the corresponding pressure differences given in Table 2, as required by the relevant specification.

Table 2 – Head-of-water and corresponding pressure differences

Head of water m	Corresponding pressure difference (at 25 °C) kPa
0,15	1,47
0,40	3,91
1	9,78
1,50	14,7
4	39,1
6	58,7
10	97,8
15	147,0

When a tank is used, the specified head of water shall be measured above the highest point of the specimen. When a high-pressure water chamber is used, the water pressure shall be adjusted to the pressure difference of Table 2.

The duration shall be specified in the relevant specification. Preferred values shall be 30 min, 2 h, 24 h. The temperature of the specimen and of the water shall be between 15 °C and 35 °C. During the conditioning period the difference in temperature between the water and the specimen shall be as small as possible, but not greater than 5 K.

During immersion, the specimen under test shall not be in operation, it shall be switched off and its movable parts shall be at rest, if not specified otherwise.

8.6 Recovery

The specimen shall be thoroughly dried externally by wiping or by applying a blast of air at room temperature, unless otherwise specified by the relevant specification.

8.7 Final measurements

The specimen shall be examined for water penetration and shall be visually inspected and electrically and mechanically checked as required by the relevant specification.

8.8 Information to be given in the relevant specification

When Test Qf is included in the relevant specification the following details shall be given as far as they are applicable:

	Subclause
a) Electrical and mechanical checks prior to conditioning	8.3
b) Preconditioning procedure	8.4
c) Position during conditioning	8.5
d) Whether a wetting agent may be used or not	8.5
e) Head-of-water or pressure difference	8.5
f) Duration of conditioning	8.5
g) Electrical and mechanical checks after recovery	8.7

9 Test Qk: Sealing tracer gas method with mass spectrometer

9.1 Object

To verify the hermetic sealing of specimens by evaluating the leak rates with a tracer gas and a mass spectrometer.

Helium is the tracer gas most used with a mass spectrometer and the test has been written with reference to this gas.

9.2 Scope of Test Qk

Test Method 1 is primarily applicable to specimens of small volume whose surfaces are not likely to impair the results by too high a retention of adsorbed helium (such as braids, joints, organic materials, paint) unless they have been suitably neutralized before the detection phase.

Test Method 2 is intended for specimens that have been filled, during manufacture or for the requirements of this test, with a mixture containing a large proportion of helium.

Test Method 3 (jet and pocket methods) is intended for specimens to be mounted on bulkheads or panels.

Test Method 3 should be used judiciously, because it is possible to release sufficient helium into the room to swamp the spectrometer, resulting in the suspension of the test until the room has been ventilated.

The method should not be used where a numerical acceptance limit for leak rate is specified (see Annex E). Owing to this fact, acceptance criteria should be specified between all parties.

9.3 General description of the test

Test Method 1 consists of impregnating the specimen, which has been previously carefully cleaned and dried, by placing it in a chamber containing a pressurized helium mixture. Helium penetrates the inner volumes of the specimen. After a given time, the specimen is placed in a chamber which is then pumped out and connected to a mass spectrometer. Helium that exudes out of the specimen is pumped into the mass spectrometer and its outflow is measured. The measured helium leak rate can then be transformed by calculation into the equivalent standard leak rate to make possible the comparison of specimens of similar volumes tested under different conditions. The comparison between specimens having different volumes can still be significant if one compares the ratios

$$\theta = \frac{p_0 V}{L} \quad (1)$$

which are the time constants of the specimens concerned. The interrelation of the test parameters is described in Annex D, guidance on Test Qk is given in Annex E.

Test Method 2 is like Test Method 1 except for the impregnation phase which is omitted. This test shall normally be completed within 30 min after sealing. For large specimens, depending on the internal volume and the thickness of the envelope, a longer delay can be necessary. In the case of small specimens, it shall be carried out immediately after sealing.

It is not suitable for general hermetic seal testing such as that required at the end of other environmental tests.

Immersion and detection pressures shall be so chosen that they are compatible with the greatest possible pressure the specimen can withstand without seal deterioration.

If no leak is detected by this test, Test Qc or an equivalent test is applied to the specimen.

Test Method 3 consists of exposing one side of the specimen to a vacuum by placing it against a suitable orifice of a vacuum chamber connected to a mass spectrometer. The visible side of the specimen is then covered by a sealed flexible pocket filled with helium (alternative a)) or swept by a fine jet of helium (alternative b)).

Alternative a): If leaks occur, some of the helium in the pocket is sucked into the vacuum chamber. The size of the fault (but not its location) can be determined from the readings on the mass spectrometer.

Alternative b): Helium is detected by the detector when the helium jet passes over a sealing fault (leak). The location and size of the leak can then be determined from the readings on the mass spectrometer.

9.4 Test Method 1

9.4.1 General

Test Method 1 is commonly used for specimens that are not filled with helium during manufacturing.

9.4.2 Severities

A severity is defined as the minimum time constant required for the application. The relevant specification shall state the applicable severity chosen from Table 3. In cases where it is necessary to specify a different severity, the relevant specification shall state all relevant test parameters (see Annex D).

Table 3 – Severities and test conditions (and corresponding equivalent standard leak rates)

Immersion pressure (absolute) $P_a \cdot 10^5$	Immersion time (minimum) t_1 min	Severity 6 h ($\theta = 2 \cdot 10^4$ s)		Severity 60 h ($\theta = 2 \cdot 10^5$ s)		Severity 600 h ($\theta = 2 \cdot 10^6$ s)		Equivalent standard leak rate L $\text{Pa} \cdot \text{cm}^3/\text{s}$
		Internal volume V' cm^3	Measured leak rate (maximum) R $\text{Pa} \cdot \text{cm}^3/\text{s}$	Internal volume V' cm^3	Measured leak rate (maximum) R $\text{Pa} \cdot \text{cm}^3/\text{s}$	Internal volume V' cm^3	Measured leak rate (maximum) R $\text{Pa} \cdot \text{cm}^3/\text{s}$	
2	70							$\text{Pa} \cdot \text{cm}^3/\text{s}$
3	45							$5 \cdot 10^{-4}$ to $1,5 \cdot 10^{-3}$
4	30					0,02 to 0,2	10^{-5}	
5	30							
8	20							
2	70							
3	45							
4	30					0,1 to 1,0	10^{-4}	$5 \cdot 10^{-3}$ to $1,5 \cdot 10^{-2}$
5	30							
8	20							
2	70							
3	45							
4	30					1,0 to 10	10^{-3}	0,05 to 0,15
5	30							
8	20							
2	240							
3	160							
4	120							
5	90							
8	60							
2	480							
3	320							
4	240							
5	190							
8	120							

9.4.3 Preconditioning

The specimen shall be so cleaned that contaminants such as grease, fingerprints, flux and lacquer which are likely to conceal leaks or to adsorb helium are removed. After cleaning, the specimen shall be stoved dry to eliminate traces of solvents, capillary condensations, etc., which can conceal existing leaks. The test shall be conducted on a specimen without any external attachment likely to entrap helium. A preliminary study should be made for each individual technology used to optimize the preconditioning process.

9.4.4 Initial measurements

There are no initial measurements required for Test Method 1.

9.4.5 Test parameters

The test parameters and the acceptable limit for the measured leak rate R are given in Table 3, as a function of internal volume of the specimen, according to the severity and test method chosen by the relevant specification. The interrelation of the test parameters is described in Annex D.

9.4.6 Conditioning

Guidance on Test Qk is given in Annex E.

The specimen shall be placed in a sealed chamber.

When the maximum immersion pressure called for by the relevant specification is not greater than 200 kPa (absolute), one of the following procedures shall be used at the option of the experimenter:

- either reduce the pressure within the chamber to an absolute value of the order of 0,1 kPa to 1 kPa;
- or sweep the chamber with helium.

When the immersion pressure called for by the relevant specification is greater than 200 kPa, neither of the above procedures is required.

The chamber shall be filled with a helium mixture, containing 95 % helium minimum, if not specified otherwise, and then pressurized at an absolute pressure and for a length of time chosen from Table 3. The pressure shall not be greater than the maximum pressure stated by the relevant specification for this type of device.

NOTE The immersion time t_1 and measured leak rate R are interrelated with immersion pressure p , the minimum time constant θ (severity) and equivalent standard leak rate L (see Table 3). A nomogram for a quick computation of these interrelated parameters is given in Figure D.1, and explanations in Annex D.

9.4.7 Recovery

After it has been removed from the pressure vessel, the specimen shall be subjected to standard atmospheric conditions for testing in order to eliminate helium adsorbed by external surfaces and so avoid unacceptable parasitic signals during the final measurements. Dry gas blowing is permissible for accelerating recovery.

9.4.8 Gross leaks

Before this test, the absence of gross leaks shall be checked by using any suitable method, such as those described in Test Qc, as specified by the relevant specification.

9.4.9 Final measurements

The specimen shall be transferred to a chamber connected to the leak detector system which is so depressurized that the mass spectrometer can operate normally.

The helium measured leak rate R is then determined by comparison with that of a calibrated standard leak. It shall be smaller than the maximum value given in Table 3 for the minimum time constant θ (severity) required by the relevant specification.

The determination of the measured leak rate R should preferably be completed within 30 min of removal from the pressurizing vessel, unless practical experience reveals that a longer ventilation time is necessary to consider the resorption effects.

NOTE The effect of a longer ventilation time can be estimated using the information given in Annex D.

9.5 Test Method 2

9.5.1 General

Test Method 2 is commonly used for specimens filled with helium during manufacturing or for the requirements of this test.

9.5.2 Preconditioning

The specimen shall contain a gaseous mixture where the helium concentration is equal to or greater than 25 % in terms of pressure. Periodical checks shall be made to ensure that the gas mixture used contains the required concentration of helium.

If appropriate, the relevant specification shall state any necessary mounting conditions.

9.5.3 Initial measurements

There are no initial measurements required for Test Method 2.

9.5.4 Conditioning

There is no further conditioning required for Test Method 2 as the specimens are already prepared.

9.5.5 Gross leaks

In addition to this test, the absence of gross leaks shall be checked by using any suitable method, such as those described in Test Qc, as specified by the relevant specification.

9.5.6 Final measurements

Upon completion of the seal, the specimen shall be transferred to a chamber connected to a mass spectrometer type leak detector, which is then depressurized so that the mass spectrometer can operate normally.

The measured leak rate R is determined by comparison with that of a calibrated standard leak. This measurement shall be completed within 30 min after specimen sealing except for special conditions.

The measured leak rate R is converted to the time constant θ by applying the following formula:

$$\theta = 2,7 \frac{cVp_o}{R} \quad (2)$$

where

V is the internal volume of the specimen (cm^3);

c is the actual concentration of helium in the gaseous mixture in use (cm^3/m^3);

p_0 is the atmospheric pressure (10^5 Pa);

R is the measured leak rate of helium ($\text{Pa} \cdot \text{cm}^3/\text{s}$);

θ is the required time constant (s).

The relevant specification shall state the minimum time constant or the maximum acceptable equivalent standard leak rate L . Suggested values for the time constant are $2 \cdot 10^5 \text{ s}$ and $2 \cdot 10^4 \text{ s}$.

9.6 Test Method 3

9.6.1 General

Test Method 3 is commonly used for specimens to be mounted on bulkheads or panels.

9.6.2 Preconditioning

Clean the specimen to remove all contaminants, such as grease, fingerprints, flux or varnish, likely to conceal leaks. After cleaning, dry the specimen in an oven to remove all trace of solvents, capillary condensation, etc., which can also conceal leaks.

9.6.3 Initial measurements

With the measuring orifice hermetically isolated from the chamber by a valve, evacuate the chamber, and when the pressure is sufficiently low to allow proper functioning of the mass spectrometer, connect the chamber to the latter.

NOTE The residual signal is caused by the spectrometer with no helium injection.

Check the proper functioning of the spectrometer with a reference helium leak.

9.6.4 Conditioning

Place the specimen over the measuring orifice and expose it to the vacuum by opening the isolating valve. Check that the depression remains sufficient for the proper functioning of the mass spectrometer and continue evacuating until the residual signal stabilizes itself at a value approximately equal to that recorded previously.

Alternative a): Cover the outer side of the specimen with a flexible pocket, of plastic for example, filled with helium. Note the readings of the mass spectrometer.

Alternative b): Sweep the whole outer side of the specimen with a fine jet of helium at low pressure. Note the readings of the mass spectrometer.

If possible, the helium pressure should be specified in the relevant specification.

9.6.5 Final measurements

The measured leak rate R is then determined by comparison with that of the reference leak, the residual signal being deducted.

9.7 Information to be given in the relevant specification

	Subclause
a) Test method	9.2 and 9.3
Test Method 1	
b) Severity	9.4.2
c) Test parameters	9.4.5
d) Test parameters (special cases)	Annex D
e) Maximum immersion pressure allowed for the type of device	9.4.6
f) Gross leaks: detection method to be used	9.4.8
Test Method 2	
g) Time constant	9.5.3
h) Gross leaks: detection method to be used	9.5.4
i) Mounting conditions (if necessary)	9.5.2
Test Method 3	
j) Alternative a) or b)	9.6.4
k) Helium pressure	9.6.4
l) Acceptance criteria	9.2

10 Test QI: Bomb pressure test**10.1 Object**

To determine the effectiveness of seals of specimens whose electrical characteristics will be affected by penetration of liquid.

10.2 Scope of Test QI

This test can be used for the detection of leaks which would result in air leak rates greater than $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$. It is applicable only to specimens that can withstand external overpressure.

Guidance on Test QI is given in Annex F.

10.3 General description of the test

This method consists in allowing a test liquid to penetrate through a leak to the interior of the specimen under test. This method is commonly known as the bomb pressure test.

The test liquid shall possess the property of producing detectable changes in the electrical characteristics of the specimen. Test liquids such as water or a mixture of water and alcohol are widely used. In each case, it should be verified that the test liquid does not react chemically with the surface of the specimen.

Assessment of the leak is achieved by measuring those specified electrical parameters which are influenced by the penetration of the test liquid (for example a suitable alcohol). Adding pigment to the test liquid can show the path of penetration after opening the specimen under test. As it usually requires some time for the penetration of the test liquid to affect the electrical characteristics, repeated measuring, separated by short periods of storage, can be necessary.

The maximum sensitivity of the method is limited at approximately $1 \text{ Pa} \cdot \text{cm}^3/\text{s}$. No quantitative information on the leak rate can be obtained.

10.4 Initial measurements

The specimens shall be visually inspected and electrically and mechanically checked as required by the relevant specification.

10.5 Conditioning

The pressure vessel (bomb) shall contain the type of test liquid as required by the relevant specification. The test liquid shall be alcohol or water with a detergent or both, if not specified otherwise.

The test liquid shall be at standard atmospheric conditions for testing or at the temperature specified by the relevant specification. The specimens shall be placed in the pressure vessel in such a manner that they are fully submerged in the test liquid.

The pressure within the test vessel shall be raised to the value specified in the relevant specification. The maximum pressure depends mainly on the construction of the specimen. It should normally not exceed 500 kPa (50 N/cm²).

The duration of the conditioning shall be as specified by the relevant specification but shall normally be not more than 16 h. In special cases, i.e. when using lower pressures, the duration may be raised to 24 h.

The duration of the conditioning can be reduced when the pressure is raised, but care should be taken that the applied pressure does not exceed the maximum value the specimen can withstand. A pressure of 250 kPa/cm² (25 N/cm²) is sufficient for a number of applications.

The pressure in the vessel shall then be reduced to atmospheric pressure and the specimens shall be removed from the vessel.

10.6 Recovery

If required by the relevant specification, the specimens shall be cleaned by means of a suitable liquid. In this case, the type of cleaning liquid shall be specified in the relevant specification. The specimens shall be dried by applying a blast of air at laboratory temperature for a short period.

The specimens shall then be subjected to standard atmospheric conditions for recovery for a period as required by the relevant specification.

10.7 Final measurements

The specimens shall be visually inspected and electrically and mechanically checked as required by the relevant specification. In case of doubtful results the measurements shall be repeated after a suitable recovery period.

10.8 Information to be given in the relevant specification

When Test QI is included in a relevant specification, the following details shall be given as far as they are applicable:

	Subclause
a) Measurements prior to conditioning	10.4
b) Type of test liquid	10.5
c) Temperature of the test liquid	10.5
d) Pressure in the test vessel	10.5
e) Duration of conditioning	10.5
f) Cleaning and type of liquid	10.6
g) Duration of recovery	10.6
h) Measurements after recovery	10.7
i) Repeated recovery and repeated measurements	10.7

11 Test Qm: Tracer gas sealing test with internal pressurization

11.1 Object

To define methods for measuring fine leaks by accumulation or for detecting them by probing using a tracer gas easily separable from air components, for example sulphur hexafluoride.

11.2 Scope of Test Qm

This test is applicable to any specimen able to withstand internal pressurization. It allows the detection of leak greater than approximately $10^{-8} \text{ Pa} \cdot \text{m}^3/\text{s}$.

11.3 General description of the test

11.3.1 Total method and local method

From a single operation the total leak flow can be determined, but not, simultaneously, the number of leaks or their location. It is therefore necessary to distinguish "total methods", allowing the measurement of the total leak flow, from "local methods", allowing the location of individual leaks for rectification if required.

EXAMPLE The cumulative test is a "total method"; the probing test is a "local method".

Another possibility is an "intermediate method" in which the leak is accumulated (total method) from a part of the specimen (partial localization) and this intermediate method then applied to every part of the specimen.

11.3.2 Corresponding leak rate

When the tracer gas is only one component of the gas mixture in the specimen, the measured leak rate shall be multiplied by a correction factor which can generally be taken as the ratio of the total internal pressure to the partial pressure of the tracer gas.

If the test pressure is different from the service pressure, the leak rate can generally be extrapolated linearly with the absolute pressure, assuming that the leak rate is of an order equal to, or less than, $10^{-6} \text{ Pa} \cdot \text{m}^3/\text{s}$ and that the pressure change does not modify the shape of the leak path.

If the test gas is different from the service gas, the conversion law can be determined by tests or calculated. Generally, the ratio of fine leaks is inversely proportional to the square root of the ratio of the apparent molecular masses (the apparent molecular mass for air is 29).

11.3.3 Test Method 1: Cumulative test

The specimen of which the sealing shall be assessed is internally pressurized with a tracer gas. After allowing time for the leak rate to stabilize, the whole specimen (or a part of its surface) is enclosed in a gastight sheath in which the gas leaking from any defects accumulates for a measured duration. This collected gas is then measured and the leak rate calculated.

11.3.4 Test Method 2: Probing test

The specimen in which any leaks shall be detected is internally pressurized with a tracer gas. After allowing time for the leak rate to stabilize, the probe of a leak detector is placed near to the specimen and moved over its surface. If the concentration of tracer gas reaches the threshold level of the detector, it gives a signal permitting the leak to be localized. The probing test does not allow the leak rate to be measured. Nevertheless, it is sometimes possible to estimate if a given leak rate has been exceeded. In those cases, the need to know the threshold level of the leak detector and the testing conditions (ambient pollution level, speed of traverse of the probe, nature of the specimen, etc.) should be considered.

11.4 Preconditioning

Seal every unused opening carefully to avoid any interference with measurement of the leak from the part of the specimen under test. If an opening is to be used later, the sealing of connections to the added part should be tested. Clean and dry the specimen.

The relevant specification shall specify any additional preconditioning.

11.5 Conditioning

11.5.1 General

The relevant specification shall specify:

- a) the method to be used (Test Methods 1 or 2 or "intermediate");
- b) whether the specimen is operating or not, and if not, its position (open, closed, cocked, etc.).

Further information on Test Qm is given in Annex G.

11.5.2 Test Method 1: Cumulative test

11.5.2.1 Procedure

Pressurize the specimen. The relevant specification shall specify the test pressure. If the filling gas is to be reused, pressurization is generally preceded by evacuation.

Wait for the time specified by the relevant specification to allow the leak rate to stabilize.

Place in position the sheath determining the volume of measurement and measure the initial tracer gas concentration C_0 at time t_0 .

After a time depending on the sensitivity, measure the final concentration C_1 at time t_1 .

NOTE It is also possible to perform a cumulative test with an all-or-nothing meter with a known threshold level by arranging for the initial concentration to be, for practical purposes, zero, and inserting the probe in the volume of measurement at uniform time intervals until the signal occurs.

11.5.2.2 Interpretation of the results

Meter readings can be converted into concentrations using a calibration chart that is periodically checked.

The leak rate R for a specimen is calculated by the formula:

$$R = \frac{V_m (C_1 - C_0)}{t_1 - t_0} 10^{-6} p_e \quad (3)$$

where

R is the leak rate (Pa · m³/s);

V_m is the capacity of the volume of measurement (m³);

$t_1 - t_0$ is the time interval (s);

C_1 and C_0 are the tracer gas concentrations (cm³/m³);

p_e is the pressure at the outer surface of the specimen, that is 10⁵ Pa.

The specimen shall be considered as accepted if the measured leak rate does not exceed the maximum value that shall be admitted by the relevant specification.

11.5.3 Test Method 2: Probing test

11.5.3.1 Procedure

Pressurize the specimen. The test pressure shall be that specified by the relevant specification. If the filling gas is to be reused, pressurization is generally preceded by evacuation.

Wait for the time specified by the relevant specification to allow the leak rate to stabilize.

Move the probe slowly over the surface of the specimen, particularly near the places in which a leak is most likely (for example welds, gasketed connections between two parts). If a signal occurs, note the corresponding position of the probe.

In the general case where this method is used to locate leaks measured during a previous cumulative test, preconditioning (see 11.4) will already have been carried out.

11.5.3.2 Interpretation of the results

The test is successful if the leaks have been located.

11.6 Information to be given in the relevant specification

When Test Qm is included in a relevant specification, the following details shall be given as far as they are applicable:

	Subclause
a) Whether the leak rate may be estimated using Test Method 2	11.3.4
b) Additional preconditioning	11.4
c) Method to be used (Test Methods 1 or 2 or "intermediate")	11.5.1 a)
d) Whether the specimen is operating or not, etc.	11.5.1 b)
e) Test pressure and time for stabilization for the test gas	11.5.2.1 11.5.3.1
f) Maximum leak rate	11.5.2.2

12 Test Qy: Pressure rise sealing test

12.1 Object

To determine the effectiveness of seals of specimens with an enclosed gas-filled (air or inert gas) space e.g. a component not filled with impregnant. This test method facilitates automatic testing on components produced in high volume.

12.2 Scope of Test Qy

The test can be used for the detection of leak rates down to approximately $10^{-5} \text{ Pa} \cdot \text{m}^3/\text{s}$. It is applicable only to components able to withstand the necessary decompression during the test, without suffering permanent distortion or other damage, such that the extent of any potential source of leak is changed and that the internal volume is smaller or equal to 5 cm^3 .

12.3 General description of the test

12.3.1 Test method

The test method consists in observing the rate of the pressure rise in a test chamber containing the test specimen when the rapid evacuation required to reach the adequate low level of pressure is stopped, suddenly and after a predetermined time.

Guidance on Test Qy is given in Annex H.

12.3.2 Test equipment

Figure 2 illustrates a typical installation for the sealing test using the pressure rise test procedure.

With the air inlet open, the specimen is placed and sealed in the test chamber. After closing the inlet valve the chamber is rapidly evacuated until a pressure of between 3 kPa and 4 kPa is reached. The pump valve is then closed, and the pressure rise Δp is recorded in the test chamber (in the volume of measurement) occurring during a test time Δt . The result obtained is used to calculate the leak rate.

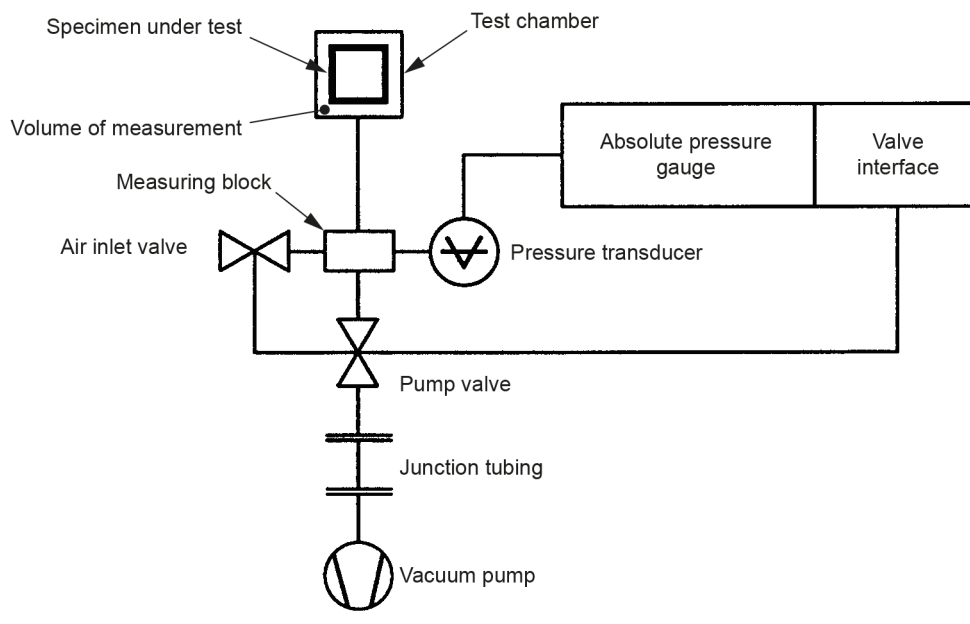


Figure 2 – Typical installation for sealing test using the pressure rise test procedure

The test sequence should preferably be directed by a suitable control system. The capacity of the vacuum pump shall enable the low pressure of 3 kPa to be reached within the predetermined evacuation time. The suction volume of the vacuum pump shall fit the air volume to be evacuated. To achieve a volume of measurement as small as possible, the pressure in the volume of measurement shall be detected by using a piezoelectric transducer.

Figure 3 shows the behaviour of the test chamber pressure during the test procedure.

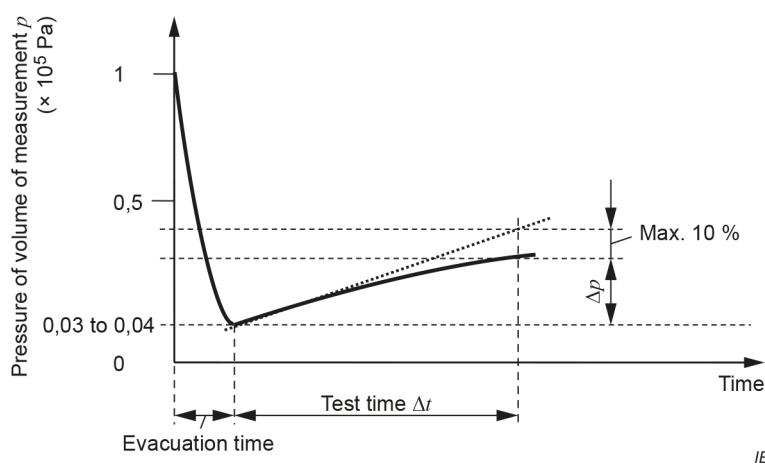


Figure 3 – Pressure of volume of measurement versus time during the sealing test using the pressure rise test procedure

12.3.3 Calculation of the leak rate R

The leak rate R is calculated according to the following formula:

$$R = \frac{\Delta p \times V_m}{\Delta t} \quad (4)$$

where

Δp is the pressure rise during the test time Δt (Pa);

V_m is the volume of measurement (m^3);

Δt is the test time (s).

The specimen shall be considered as accepted if the measured leak rate does not exceed the maximum value admitted by the relevant specification.

12.4 Calibration of the test equipment

The test equipment shall be calibrated with a calibrated specimen. The pressure rise obtained using the calibrated specimen instead of a test item represents a constant, which shall always be subtracted from the measured total pressure rise Δp . For the calibration of the test equipment, the vacuum pump shall be operated with the same flow and for the same duration as for the test.

12.5 Test time

The test time should be no longer than the time required to allow a maximum of 10 % deviation from the linear extrapolation of the pressure increase curve (see Figure 3). Assuming this curve has an exponential behaviour with a time constant τ , the test time Δt chosen should not be greater than approximately $0,2 \tau$.

The evacuation time necessary to reach low pressure should not be longer than approximately 5 % of the time constant mentioned above. In practice, an evacuation time of 0,02 s to 0,5 s and a test time of 1 s to 10 s may be adequate.

To determine the evacuation time required, a calibrated specimen should be used. This shall be either a specially made dummy with size, form and surface materials equal to the test piece, or a completely gas-tight specimen showing the behaviour illustrated in Figure H.1 a).

Figure H.1 shows limiting cases of the behaviour of the pressure in the test chamber.

12.6 Evaluation of the volume of measurement

The volume of measurement is the total space which shall be evacuated. For its evaluation, any suitable physical measuring method may be used.

A possible procedure consists in connecting one end of a U-tube to the inlet valve leaving the other one open to the ambient atmosphere. The tube is filled with a liquid of low vapour pressure such as oil. Displacements of the fluid column shall be calibrated in volume and pressure units. After the calibration, with the air inlet open, the specimen is placed and locked into the test chamber at ambient pressure. The inlet valve is then closed and the test chamber evacuated to the low test pressure. The pump valve is then closed and the inlet valve opened. From the volume of the incurred displacement of the fluid, the volume of measurement V_m can be determined up to first-order corrections according to the following formula:

$$V_m = \Delta V_f + \Delta V_f \frac{p}{p_o} + V_d \frac{p_d}{p_o} \quad (5)$$

where

V_m is the volume of measurement;

ΔV_f is the volume of the displacement of the fluid column;