BRITISH STANDARD

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Non-destructive testing — Leak testing — Tracer gas method

The European Standard EN 13185:2001, with the incorporation of amendment A1:2003 has the status of a British Standard

ICS 19.100

British Standards

National foreword

This British Standard is the official English language version of EN 13185:2001, including amendment A1:2003. Together with BS EN 13184:2001 it supersedes BS 3636:1963 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 May 2001

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English version

Non-destructive testing — Leak testing — Tracer gas method

(includes amendment A1:2003)

Essais non destructifs — Contrôle d'étanchéité —
Méthode par gaz traceur
(inclut l'amendement A1:2003)

Zerstörungsfreie Prüfung — Dichtheitsprüfung —
Prüfgasverfahren
(enthält Änderung A1:2003)

This European Standard was approved by CEN on 18 January 2001, and amendment A1 was approved by CEN on 20 November 2003.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 138, Non-destructive testing, the Secretariat of which is held by AFNOR**.**

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2001, and conflicting national standards shall be withdrawn at the latest by September 2001.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

Annex A is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This document EN 13185:2001/A1:2003 has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This Amendment to the European Standard EN 13185:2001 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This standard describes the techniques to be applied for the detection of a leak, using a tracer gas and a tracer gas specific leak detector.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 473, *Qualification and certification of NDT personnel — General principles.*

EN 1330-8, *Non-destructive testing — Terminology — Part 8: Terms used in leak tightness testing.*

EN 1779, *Non-destructive testing — Leak testing — Criteria for method and technique selection.*

prEN 13192:2001, *Non-destructive testing — Leak test — Calibration of gaseous reference leaks.*

prEN 13625:2001, *Non-destructive testing — Leak test — Guide to the selection of instrumentation for the measurement of gas leakage*.

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1330-8 apply.

4 Personnel qualification

It is assumed that leak testing is performed by qualified and capable personnel. In order to provide this qualification, it is recommended to certify the personnel in accordance with EN 473 or equivalent.

NOTE For pressure equipment see directive 97/23/EC (Annex I, paragraph 3.1.3): “For pressure equipment in categories III and IV, the personnel must be approved by a third party organization recognized by a Member State”.

5 Principles of detection

A partial pressure difference of tracer gas is created across the boundary of the object to be tested. The tracer gas, having passed through the leak, is revealed by its physical or chemical properties. Chemical detection is generally based on reactions that cause a local colour change (the object surface shall therefore be visible).

Detection based on physical properties usually involves a sensor, for example:

- a mass spectrometer, tuned for the specific tracer gas used (generally helium-4);
- an alkali ion diode, for halogen gas, and electron-capture equipment (i.e. for SF_6);
- a Pirani gauge, for tracer gas with thermal conductivity different from that of the ambient atmosphere;
- a photometer, with band-pass filter in the frequency range of the tracer gas absorption or emission.

These types of detection generally give an electrical signal which varies with the tracer gas partial pressure.

6 Generation and detection of tracer gas flow

Two basic techniques are used, see EN 1779.

6.1 Tracer gas flows into the object (Group A techniques)

A pressure difference across the wall is obtained either by evacuation of the object, e.g. through a connection or by placing it in a pressurized chamber. Usually the test object is evacuated. Tracer gas is then applied to the external surface using a probe jet or by enclosing the object (totally or partially) in a hood or chamber filled with the tracer gas. Tracer gas leakage into the test object is detected by a sensor within or connected to the internal volume.

6.2 Tracer gas flows out of the object (Group B techniques)

The object is filled with a tracer gas. A pressure difference across the wall is obtained either by pressurization of the object, e.g. through a connection or by placing it in a vacuum chamber. The tracer gas is collected on the outside surface by a sampling probe or by accumulation into a hood or chamber. Tracer gas can also be detected by chemical reactions.

A special technique (bombing) may also be used. This involves pressurization of a sealed object to force tracer gas into its internal cavities, if a leak exists. The object is then placed in a vacuum chamber and escaping tracer gas is detected (usually this procedure is used only with helium-4).

This method is applicable to specimens with small free internal volumes (in the order of a few cubic centimetres).

7 Apparatus — see prEN 13625:2001

The test apparatus can include part or all of the following:

7.1 Leak detector or chemical reagents able to detect the selected tracer gas.

7.2 Calibration leaks, calibrated for discharge into vacuum and/or against atmospheric pressure; refer to prEN 13192:2001.

7.3 Pressure and temperature gauges

7.4 Tracer gas or certified gas mixture.

7.5 Auxiliary vacuum systems

7.6 Hood, vacuum or pressurizing chamber, jet or sampling probe.

7.7 Purging dry gas, liquid nitrogen (for cold trap), if necessary.

7.8 Equipment for tracer gas treatment-recovery.

7.9 Equipment for test area ventilation.

7.10 Data recording equipment.

8 Object preparation

The object to be tested shall be adequately cleaned, degreased and dried. Openings and apertures which are not involved in the test must be closed with test seals, e.g. plugs, welding, suitable material and gaskets. Whenever possible, testing should be carried before plating, painting or the application of ultrasonic couplant. If the object has to be evacuated, the presence of porous or plastic materials should be avoided. This helps to avoid spurious indications (virtual leaks), and shortens the clean-up time.

The connections between the object, the pumping system, the leak detector (LD) and the calibration leaks used shall be suitable and checked for tightness.

9 Group A techniques, tracer gas flowing into the object.

These techniques are applicable to an object that can be evacuated or withstand an external test pressure. The tracer gas is applied on the outer surface of the object and the LD is connected to the internal volume. If the LD is of Mass Spectrometer type (MLSD), the pumping system of the MSLD itself can be used to evacuate directly small items under test.

Larger objects need an auxiliary pumping system. In this case, the loss of sensitivity shall be considered, as only part of the tracer gas will enter the LD.

Three techniques may be used — refer to EN 1779:

- Vacuum technique (Total) – A.1

The object, placed in an enclosure (a bag or a chamber), is evacuated and connected to the detector. The enclosure is then filled with the tracer gas or a gas mixture containing the tracer gas. This technique allows the evaluation of the leakage rate but does not permit precise location of the leaks.

When the purpose of the leak testing is the determination of the acceptability of the test object against a specified leakage rate, only the integral technique shall be used. In this case, the tracer gas concentration, pressure and temperature shall be measured and the homogeneity of the gas mixture shall be ensured. Further the enclosure shall be gas-tight and, preferably, rigid.

- Vacuum technique (Partial) – A.2

The object to be tested is evacuated and connected to the detector. Suspect areas are then covered by a suitable gas-tight enclosure filled with tracer gas.

- Vacuum technique (Local) – A.3

The object to be tested is evacuated and connected to the detector. Suspect areas on the external surface of the object are sprayed with tracer gas. Leaks can be localized using this technique but it is not possible to measure the total leakage rate.

9.1 Initial system set up procedure

9.1.1 The LD shall be adjusted in accordance with manufacturer's instructions, using a calibration leak (if required the leak shall be "standard"). If an MSLD is used, a leak for discharge to vacuum has to be connected directly to the inlet of the LD, or the built-in leak for the calibration is to be used.

9.1.2 The object is connected to the LD and then evacuated to a suitable pressure, either by LD pumping system or by an auxiliary pumping system. This is determined by the maximum inlet pressure of the LD.

9.1.3 The initial background signal shall be measured.

9.1.4 The maximum signal for the specified calibration leak connected to the object shall be recorded to verify the system sensitivity. The ratio of the pumping speed of the LD to the pumping speed of the auxiliary system shall not be altered.

9.1.5 For large objects or complex systems, the “response time” of the system shall be measured by means of a suitable calibration leak the rate of leakage of which is as near as possible to the specified maximum allowable leakage. Unless otherwise specified, this leak shall be connected to the object under test, via an isolation valve, in the most unfavourable position, to determine the response time.

An auxiliary line should be provided, if possible, to evacuate the volume between the leak outlet and the isolation valve. In any case, care should be taken to avoid the inlet of the accumulated gas in the system. The response time is the time from opening of the valve until the 90 % of the maximum stable signal is reached.

The signal amplitude and the response time shall be taken as reference for the test. The system layout or pumping speed shall not be changed.

9.1.6 The isolation valve to the leak, used for time response determination, is then closed and the clean up time is measured.

9.1.7 To evaluate large leaks that saturate the LD signal, the sensitivity of test can be reduced. This reduction can be achieved either by lowering the fraction of tracer gas in the mixture or increasing the pumping speed of the auxiliary system. The factors established in paragraphs 9.1.4 to 9.1.6 shall be determined for the new conditions.

9.2 Vacuum technique (total) test procedure (A.1)

After the initial set-up has been performed the following step shall be taken.

9.2.1 The object is placed into the auxiliary enclosure (bag or chamber) and it is then evacuated. If the enclosure is a flexible bag (usually plastic), it shall be sufficiently large to enclose the perimeter of the object.

9.2.2 A preliminary evacuation of the enclosure may be useful. If the enclosure is a flexible bag, it should lay down well against the object walls (without tearing). After it has been evacuated the tracer gas is admitted. If the enclosure has not been evacuated, it should be adequately purged using dry tracer gas, or a gas mixture containing tracer gas, to ensure that the tracer gas concentration is homogeneous and as intended. The person performing the test shall note the volume fraction of the tracer gas in the mixture, so that the corresponding correction in subsequent measurements can be made. If a flexible bag is used, it shall be filled with gas until it is no longer touching the object walls.

9.2.3 If the enclosure is rigid, pressures shall be recorded before and after tracer gas introduction. It is possible to calculate the volume fraction of the tracer gas, applying the Boyle-Mariotte law to the recorded pressures.

9.2.4 The duration of the tracer gas admission to the auxiliary enclosure shall be at least twice the response time or 10 min, whichever is the greater. When the response time exceeds 20 min, different specifications for the admission time may be given.

9.2.5 After the appearance of any signal, it is necessary to wait until either:

- the maximum signal level is obtained: the overall leakage rate can then be calculated by comparison with the signal generated by the known leak; or
- the signal, corresponding to the maximum allowable leakage rate, is obtained: in this case the test can be interrupted for decisions.

9.2.6 The total leakage rate of the object, in molecular flow conditions, is calculated using the formula given below:

$$q_{\mathrm{G}} = \frac{q_{\mathrm{CL}} \times \left(S_{\mathrm{L}} - R_{\mathrm{L}}\right)}{S_{\mathrm{CL}} - R_{\mathrm{CL}}} \times \frac{1}{c} \times \frac{101\,325}{p} \qquad (1)$$

where:

q_{G} is the total leakage rate, in pascals cubic metres per second;

q_{CL} is the leakage rate of the calibration leak in pascals cubic metres per second (pure tracer gas);

S_{L} is the leak signal;

S_{CL} is the signal generated by the calibration leak

R_{L}, R_{CL} are the background signal associated with signal S_{L} and S_{CL}, respectively;

c is the volume fraction of the tracer gas in the gas mixture;

p is the total pressure in the auxiliary enclosure, in pascals.

When the test is carried out with a gas mixture, the volume fraction of tracer gas shall be known (certified if required) using approved procedures for mixture preparation.

If high accuracy is required, the system calibration shall be performed using a calibration leak with the test gas mixture.

9.3 Vacuum technique (partial) test procedure (A2)

When only a part of an object is to be tested (e.g. welds, thermocouple wells, personnel access covers, electrical- or mechanical feedthroughs), the auxiliary enclosure may be restricted to that area only. The duration of tracer gas admission shall be indicated in the specification, taking into account the position of the part under test relative to the pumping system and the LD.

After the initial set-up has been performed the following steps shall be taken.

9.3.1 Plastic bags or chambers are fitted to the areas to be tested using adhesive tape or suitable gaskets. These should prevent significant escape of tracer gas during the test.

The object is then evacuated.

9.3.2 Proceed as in 9.2.2 to 9.2.5.

9.4 Vacuum technique (local) test procedure (A.3)

After the initial set-up has been performed the following steps shall be taken.

9.4.1 The effect on the result of the speed of probing the surface of the test object with the spray gun shall be established by placing a conductance leak in the position of the calibration leak used in 9.1.4. The gas flow from the spray gun is adjusted and its tip is moved past the leak at the speed and distance specified for the test. The signal amplitude is recorded. If the signal is too small the scan rate should be reduced.

9.4.2 Tracer gas spraying should start at the top of the test object if the tracer gas is lighter than air. Spraying should start at the bottom if the tracer gas density is greater than air. Scanning of the areas shall be performed as stated in the test specifications.

9.4.3 When a leak is detected, it may be necessary to evaluate its influence. The leak may have to be temporarily sealed to continue the test.

9.4.4 After a leak has been found and sealed, it is necessary to wait until initial conditions are restored in the LD (clean up time). If leak location only is required, the procedure may state the signal level (% of the maximum signal) at which it is possible to continue the scan, in order to shorten the test time.

9.4.5 After all leaks have been found, it may be desirable to determine the total leakage of the object, using other suitable techniques (integral). This step may be carried out initially, to save time if no leaks exist. However, if the object contains material permeable to the tracer gas, the sorbed gas may lower the sensitivity of the subsequent test.

10 Group B techniques, tracer gas flowing out of object

These techniques are generally applicable to objects which cannot be evacuated, or to open objects. A (partial) pressure difference of tracer gas is created across the object wall. Tracer gas is admitted to the internal volume of the object and it is collected and detected in its external side. If the object to be tested is open, the gas is sprayed or applied with a bag in one side and it is collected in the other side by a vacuum box.

Seven techniques may be used. They are briefly described here.

- **Chemical detection with ammonia – B.1**
  The object is filled with anhydrous ammonia or an ammonia-nitrogen mixture to the specified overpressure. A colour-change developer (generally a mixture containing a pH indicator, e.g. bromophenol blue), applied to the outside surface, will reveal and locate leakages.
- **Vacuum box, using internal tracer gas – B.2.1**
  Large objects, containing a gas or a gas mixture suitable to be used as tracer gas, are tested by a vacuum box evacuated and connected to an LD, applied in the outer side.
- **Vacuum box applying the tracer gas on opposite side – B.2.2**
  Open objects can be tested using partial enclosures, capable of being evacuated, which are tightly applied to the wall (vacuum box, suction cup). Tracer gas is supplied on the opposite surface of the wall by a spray gun (probe jet) or by cups, filled by the tracer gas.
- **Pressure technique by accumulation – B.3**
  The object, pressurized with the tracer gas, is placed in an enclosure. After a specified time, the accumulated tracer gas is measured using an LD connected to the enclosure. The leakage size can then be estimated (or determined if the enclosure volume and pressure are known).
- **Sniffing test – B.4**
  The object is pressurized with the tracer gas (or gas mixture). Leak searching is performed on the atmospheric side of the object wall, using a sampling probe connected to an LD. This technique detects leakage and locates the leaks (direct probing).
- **Pressurization-evacuation test – B.5**
  The sealed object is subjected to a high pressure of tracer gas (bombing), usually helium, in order to force it into the object, if a leak exists. After the bombing and a flushing, to remove adsorbed tracer gas from the outer surfaces, the object is placed in a vacuum chamber, connected to an LD for the detection of the escaping tracer gas.
- **Vacuum chamber technique – B.6**
  Small objects, containing a gas suitable to be used as tracer gas are placed in a chamber. This is subsequently evacuated to a pressure lower than the internal pressure of the object. The LD is connected to the vacuum chamber. The total flow of the tracer gas from the object is measured by the L.D.

10.1 Initial system set up procedure

10.1.1 Ammonia test with colour-change reagents (B.1)

10.1.1.1 The reagents are either directly applied to the surface or supported on paper or textile band applied on the surface.

The reactivity of the reagent shall be verified by the exposure to a small quantity of gas.

10.1.1.2 A sample of the reagent shall then be applied on the object surface (away from the areas to be tested) and its colour shall be checked during all the examination time. A colour-change means the contamination with ammonia of the ambient or on the object surface.

10.1.2 Tracer gas flowing out of the object (B.2, B.3, B.4, B.6)

10.1.2.1 The LD shall be adjusted as described in 9.1.1.

10.1.2.2 To calibrate the system, calibration leaks for discharge to the atmosphere (or equivalent systems, e.g. prefabricated gas concentration), selected in the appropriate range, are required. These leaks should have a leakage rate close to the maximum allowable in the case of acceptability evaluation, or to the minimum to be detected if the aim of the test is location (for repair).

10.1.2.3 When using the sampling probe, the zero control is adjusted by closing the inlet valve or sniffing the gas over liquid nitrogen. If these devices are not available, adjustment can be made relative to the clean atmosphere (before the test starts).

If sensitivity of test has to be measured, the probe tip is held in front of a calibration leak. After a clean-up time, the calibration is repeated moving the sampling probe at the specified scan rate.

The calibration should be carried out in such a way that the test area is not flooded by the tracer gas. The calibration shall be checked frequently as the sampling probe may be plugged by dust or dirt.

10.1.2.4 If an enclosure is used, a known leak is connected to it via an isolation valve. The reading due to tracer gas concentration shall be recorded before the opening of the valve and at subsequent time intervals. This step shall be carefully carried out, due to the difficulty of purging the system, if it cannot be evacuated.

10.1.2.5 If the test is carried out in a vacuum chamber and the pumping system cannot be disconnected, the response time and the maximum readout for the calibration leak is recorded. The pumping speed shall not be altered in the subsequent test.

10.1.2.6 Remove tracer gas flow and note the signal due to the residual tracer gas in the atmosphere.

10.1.3 Pressurization — evacuation test (B.5)

10.1.3.1 The vacuum chamber with a calibration leak is connected to the MSLD. After the specified pressure is reached, the residual signal is recorded. The calibration leak is then opened and the appearance time and maximum signal is recorded.

10.1.3.2 The degassing time shall be checked using a tight sample of the same material, with same surface conditions. This sample is placed into the vacuum chamber connected to the MSLD. The flushing and/or evacuation time is the minimum time to obtain a signal clearly below the maximum allowable leakage signal. An excessive degassing time may decrease the test sensitivity or mask the large leaks.

10.2 Ammonia test procedure (B.1)

This technique is suitable for detection and location of leaks.

After the initial set-up has been performed the following step shall be taken.

10.2.1 Test object preparation

The test object shall be purged with dry hot gas to obtain a dry atmosphere. If possible, evacuation is to be preferred, since the presence of moisture may give rise to corrosion problems. The surface to which the detector reagent is applied should be neutralized using an acidic solution. This step shall be performed if the check as in 10.1.1.2 shows a diffuse colour change.

10.2.2 Reagent application

The reagent shall be applied over the specified areas.

If the reagent is in liquid form, it can be applied by brush or spray painting in a thin uniform coating. Thick coatings take longer to be developed and may result in self-discoloration. Water-based developers should be dried after application using a hot-air gun (normally from 50 °C to 60 °C) or applied on preheated surfaces to remove any moisture. Temperatures over 100 °C may damage the developer.

If the reagent is impregnated into a carrier (paper or textile), this shall be firmly fastened to the surface by adhesive tape.

After reagent application, protection with a transparent film can prevent or reduce the atmospheric contamination effects. This protection shall be applied in such a way that there is no interference with the test.

10.2.3 Ammonia pressurization

Ammonia forms explosive mixtures in air at the volume concentration in the range 15 % to 28 %.

For large leaks (greater than 1×10^{-6} Pa·m^3 /s) and for concentration less than 15 %, oil-free dry air may be used to pressurize the object.

For small leaks and higher ammonia concentrations, an inert gas (usually nitrogen) shall be used for mixture.

If a mixing device is not available, the concentration may be calculated approximately using Dalton’s law (ratio of partial pressure). The charging sequence for the object shall be as follows:

- fill with dry air or inert gas to atmospheric pressure;
- fill with ammonia to the gauge pressure equivalent to the partial pressure calculated by concentration and total pressure;
- complete the pressurization with air or inert gas to the pressure required by the specifications.

To improve the minimum detectable leakage and to shorten the test time, a pressure of 2×10^5 to 3×10^5 Pa is recommended, even if a pressure of few hundreds pascals would be sufficient for the test.

10.2.4 Impregnation time

The pressure shall be maintained for the determined time, sufficient for establishing a steady flow through any leaks. This time depends on the pressure, the wall thickness, the ammonia concentration and the amount of leakage. The suggested time is 30 min for each mm thickness. In consequence of the impregnation time, the step detailed in 10.2.3 can be also carried out before that detailed in 10.2.2.

10.2.5 Visual examination

After the impregnation time, the surface of the object with the developer shall be examined under white light, directly or with instruments able to show spots larger than 1 mm. A minimum illumination of 350 lux is required. All spots larger than 1 mm are noted and verified as follows:

a) if the reagent is painted:

  - remove the painting;
  - apply a new painting and dry;
  - if a new spot is formed, note the time of appearance;

- check the growth of the spot after 30 min and, if required, measure the diameter, in order to give an indication of the leak size;

b) if the reagent is in the form of an impregnated band:

- replace the band;
- after 15 min check if a new spot has appeared on the band side in contact with the object wall and, if required, measure the diameter to give an indication of the leak size.

10.2.6 Post test cleaning

After the examination, the pressure is released by slowly venting the mixture from the object through equipment suitable for ammonia disposal, according to local regulations. The residue is then purged by flushing with inert gas or by evacuation. Adequate flushing shall be performed before carrying out any weld repairs.

10.3 Vacuum box test procedure (B.2.1, B.2.2)

Such techniques are suitable for detection and localization of leaks. If the object is filled with a known concentration of tracer gas, technique B.2.1 is suitable for the evaluation or measurement of the leakage rate, depending on the tightness of the vacuum box seal on the object wall.

After the initial set-up has been performed, the following techniques are available.

10.3.1 Technique B.2.1

This is applicable to large enclosures containing a gas (or a gas mixture) suitable for use as tracer gas at, or below, atmospheric pressure.

10.3.1.1 The vacuum box is applied to specified test areas and is evacuated to the required pressure. The pump speed should be maintained at the minimum level necessary to achieve the required pressure, in order to optimize the test sensitivity.

10.3.1.2 The LD is connected. The pressure and the signal at time t_0 shall be recorded.

10.3.1.3 After a specified time, related to the required pressure and the system response time, the signal S_1 and the actual pressure shall be recorded. If evaluation or measurement of the leakage rate is required, the use of calibration curves, obtained from a calibration leak under the same conditions, shall be necessary.

10.3.2 Technique B.2.2

This is applicable to the open objects. In this case points 10.3.1.1 and 10.3.1.2 shall be repeated.

The tracer gas shall be applied on the opposite side using a spray gun, a cup or a bag. A signal indicates the existence of a leak.

10.4 Accumulation technique procedures (B.3, B.6)

These techniques are suitable for total leakage measurement.

The technique B.3.1 is suitable for objects which contain, or can be filled by, the tracer gas at a pressure greater than atmospheric pressure. Technique B.3.2 is applicable to sealed objects containing tracer gas at, or below, atmospheric pressure.

After the initial set-up has been performed, the following procedures are available.

10.4.1 Pressure technique by accumulation (B.3)

10.4.1.1 The object shall be purged in order to obtain a dry atmosphere. If possible, evacuation is to be preferred. The tracer gas or gas mixture containing tracer gas is admitted to a required overpressure. If a mixture is used, the procedure shall provide a final known concentration, as required by specifications.

10.4.1.2 The object is then placed in an auxiliary enclosure. This is connected to an LD capable of measuring the concentration increase of the tracer gas escaping from the object into the enclosure. The signal S_0 corresponding to the concentration c_0 of tracer gas at time t_0 (the start of the measurements) and/or the residual signal of the measuring device shall be recorded (e.g. signal resulting from atmospheric helium).

10.4.1.3 After a specified time interval (depending on the required detection limit) the signal S_1 corresponding to the concentration c_1 of tracer gas at the time t_1 shall be measured and recorded.

10.4.1.4 The concentrations c_0 and c_1 are determined from S_0 and S_1 by the comparison to a reference mixture with a known concentration of the tracer gas. The leakage rate q_G of the object should be calculated using the formula:

$$q_G = p \times \frac{V \times (c_1 - c_0)}{t_1 - t_0}$$

where:

q_G is the total leakage rate, in pascals cubic metres per second;

p, V are the pressure and volume of the auxiliary enclosure in pascals and cubic metres, respectively;

c_0, c_1 are the concentration at time t_0 and t_1 in the auxiliary enclosure at the start and end of the measurement, respectively;

t_0, t_1 are the times of start and end of the measurement, respectively.

10.4.1.5 If the volume of the enclosure is unknown, a reference leak shall be used, connected either to an enclosure with a volume similar to that of the measuring enclosure, or directly to the measuring enclosure, through an isolation valve. In the latter case, the calibration can be carried out before or after the test. The value of the reference leak shall be in the same range as the maximum allowable leakage rate. The pressure and concentration of the tracer gas shall be as close as possible to the conditions of object under test.

If the test is carried with a gas mixture containing the tracer gas, the gas of the reference leak shall be of the same mixture, if possible supplied from the outside of the object, with a special arrangement, as shown in annex A, Figure A.1.

a) If the reference leak is connected to an enclosure with similar volume, the following formula can be used to calculate leaks, if any:

$$q_G = q_L \times \frac{p_e}{p_{amb}} \times \frac{S_1 - S_0}{S_{L1} - S_{L0}}$$

where:

q_G is the leakage rate referred to the atmospheric pressure, in pascals cubic metres per second;

q_L is the leakage rate of the reference leak, in pascals cubic metres per second;

p_e	is the pressure in the enclosure, in pascals;
p_{amb}	is the room pressure, in pascals;
S_1, S_0	are signals corresponding to the concentration at the start and the end of the test;
S_{L1}, S_{L0}	are recorded signals corresponding to the concentration in the enclosure connected to the reference leak.

b) If the reference leak is connected to the same auxiliary enclosure during a part of the test, this leak is superimposed on the leaks (if any) of the object to be tested. The initial signal S_0 shall be recorded. At the time t_1, the signal S_1 shall be recorded.

At this time (after the evacuation, if necessary, of the tracer gas accumulated between the calibration leak and the isolation valve) the leak shall be opened to the enclosure.

After a further interval, at time t_2, the signal S_2 shall be recorded.

In this case:

$$q_G = q_L \times \frac{S_1 - S_0}{t_1 - t_0} \times \frac{t_2 - t_1}{(S_2 - S_0) - \left[(S_1 - S_0) \times (t_2 - t_0) / (t_1 - t_0)\right]}$$

where:

q_G	is the leakage rate referred to the atmospheric pressure, in pascals cubic metres per second;
q_L	is the leakage rate of the reference leak, in pascals cubic metres per second;
S_0, S_1	are the recorded signals corresponding to the concentrations in the enclosure respectively at the start of the test and just before the opening of the calibration leak valve;
S_2	is the signal corresponding to the concentration at time t_2;
t_0, t_1, t_2	are respectively time at the test start, at the opening of the reference leak valve, and at the final reading.

NOTE This simplified formula is valid assuming a constant leakage rate which is true if the leakage from both the test object and the reference leak are small enough to avoid appreciable alteration of object and enclosure pressures and volumes), see Figure A.2.

10.4.2 Vacuum chamber technique (B.6)

10.4.2.1 The object, containing the tracer gas, is placed in the vacuum chamber pumped down to the required pressure and connected to a tracer gas leak detector.

10.4.2.2 The total flow of the tracer gas flowing from the object into the vacuum chamber is measured.

10.5 Sniffing test (B.4)

After the initial set-up has been performed, the following steps shall be taken.

10.5.1 The object shall be purged to obtain a dry atmosphere. If possible, evacuation is to be preferred. The tracer gas or gas mixture containing tracer gas is admitted to a required overpressure. If a mixture is used, the procedure shall provide a final known concentration, as required by specifications.

10.5.2 Stabilization of the leak flow shall be allowed. The test time shall be correlated with the system response time.

10.5.3 The scanning shall be carried out on the areas indicated in the specifications.

10.5.4 The probe shall be held not more than 1 mm from the surface and shall be moved at speed not exceeding 20 mm/s.

10.5.5 All suspect areas shall be evaluated. If necessary, leaks shall be marked and temporarily repaired before continuing the scanning.

10.5.6 At the completion of the test, the tracer gas shall be evacuated from the object (if required). Test gas should never be discharged in the test area, if further testing is planned. It should be vented safely with due consideration of its effects.

10.6 Pressure evacuation procedure (B.5)

This technique covers procedures applicable to objects, not containing a gas suitable to be used as tracer gas, that are sealed prior to testing. Such objects are generally of small dimensions (e.g. semiconductor devices, hermetically enclosed relays, etc.). Leakage through the walls of this type of object is detected by pressurization of the test objects with tracer gas (bombing) prior to the test. The technique is an integral method which does not permit leak location or the detection of large leaks. Gross leaks have to be revealed by other suitable techniques.

The principle is that the test objects are placed in a bombing chamber where they are exposed to a high pressure of tracer gas. They are then placed in a vacuum chamber for testing. The steps are as follows:

- removal of air from internal cavities (evacuation);
- pressurization with tracer gas;
- surface degassing (flushing, evacuation);
- measurement in a vacuum chamber using an MSLD.

The pressure at all stages of the test shall be compatible with test object integrity and maximize the sensitivity of the test.

10.6.1 The objects, previously cleaned and dried, are placed in the chamber. The chamber shall be evacuated to the lowest pressure compatible with the object integrity and shall be maintained at this level for the specified time. This time shall be selected depending on the wall thickness.

10.6.2 The chamber shall be pressurized with tracer gas to the specified value of pressure. This shall be maintained for the time required to give the desired test sensitivity. This time depends on:

- wall thickness;
- type of material;
- leak size;
- internal volume of the objects.

10.6.3 The tracer gas shall be released at a considerable distance from the leak detector. (It may be piped out of the building or released into a holding tank to avoid increasing the tracer gas pressure in the test area.)

10.6.4 The test objects shall be flushed with dry tracer gas-free air or nitrogen, to remove sorbed tracer gas from the surface before the removal from the chamber. The flushing time shall be determined experimentally.

10.6.5 The test object is placed in the vacuum chamber, not yet connected to the mass spectrometer. Degassing is carried out during a pump-down cycle.

10.6.6 The degassing time varies according to the test object types and basically depends on the surface properties of its outside walls. In particular, the nature of the material and its surface roughness are important.

The degassing time shall be determined using a leak-tight reference object or a sample of the same material having the same surface conditions.

The reference object shall be placed in the vacuum chamber connected to the MSLD. Degassing shall be carried out in a way identical to that of the test object.

The walls can be considered to be sufficiently degassed when the desorbing gas flow reaches a level that is comparable to the expected tracer gas flow. This flow can be calculated from the acceptable leakage rate and the bombing conditions (see below).

10.6.7 The vacuum chamber for measurement shall be connected to the MSLD and a pump-down cycle initiated. After cross-over, the leakage rate signal shall be read after degassing has reached the predetermined value. A recorder shall be used to determine the dynamic equilibrium steady state indication or, after a predetermined waiting time (depending on the degassing behaviour of the test objects), the actual leakage rate reading may be taken before equilibrium. The uncertainty of measurement (given by uncertainties in the degassing time) is lower the longer the waiting time.

10.6.8 If the steady state reading can be obtained in the test, calibration shall be carried out in the usual way by using the steady state indication of a reference leak connected to the vacuum chamber. If the leakage rate reading is taken before equilibrium has been established, an equivalent reading shall be taken using the reference leak.

To obtain a measure of statistical errors, several such readings should be taken.

10.6.9 The indicated leakage rate is not the standardized total leakage, since the partial pressure of helium in the internal cavity of the test object should be considered.

The acceptable leakage rate q_L shall be used to calculate a safe reject point q_R following an equation with the parameters given below:

$$q_\mathrm{R} = q_\mathrm{L} \times p \times \left(1 - e^{-q_\mathrm{L} \times t / p_0 V}\right) \times e^{-q_\mathrm{L} \times T / \mathrm{p}_0 V}$$

where:

q_R	is the allowable leakage indication (reject point), in pascals cubic metres per second;
q_L	is the acceptable leakage rate of test object, in pascals cubic metres per second;
t	is the bombing (pressurization) time, in seconds;
p	is the bombing pressure of tracer gas, in kilopascals;
p_0	is the atmospheric pressure, in kilopascals;
T	is the waiting time between bombing and testing, in seconds;
V	is the internal volume of the test objects, in cubic metres.

NOTE 1 The reject leakage indication q_R is meaningful only as long as the bombing parameters t, T and p are kept constant.

NOTE 2 By solving the above equation for q_L and inserting the indicated leakage rate for q_R, the actual standardized leakage rate of the test object can be calculated, if required.

11 Test report

The test report shall include the following information:

a) date and site of the test;

b) the technique used (reference to this document);

c) description of apparatus employed (LD type, type and concentration or pressure of tracer gas, type, volume and tightness of auxiliary enclosures, etc.);

d) calibration operations, with the parameters and relevant signals; reference conditions;

e) test conditions (pressure, temperature, etc);

f) results of measurement carried out and calculations made (if required)

g) name of operating personnel and detail of their certification documents, if applicable.

Annex A
(informative)

Accumulation technique — calibration leak connected to enclosure of unknown volume

A schematic diagram of the calibration set-up, described in 10.4.1.5 when a mixture containing tracer gas is used, is shown in Figure A.1.

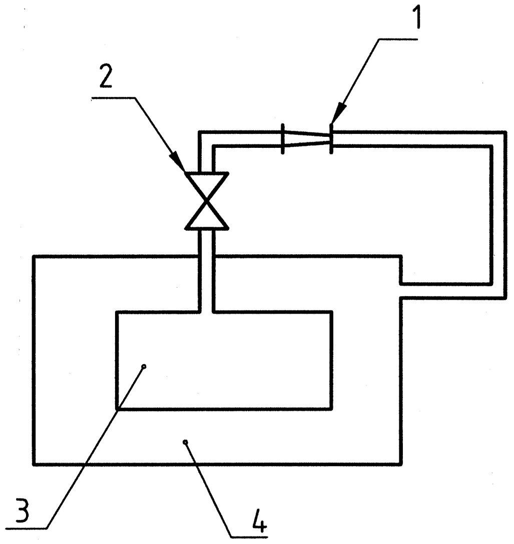
The calibration procedure described in 10.4.1.5 b) is valid in the assumption that the concentration increase in the auxiliary enclosure has a constant rate during the test time. This also means that the leakages of the object and of known leak have to be small enough to avoid appreciable alteration of object and enclosure pressures.

At the start of the test (Figure A.2), at time t_0, the signal S_0, corresponding to the initial tracer gas concentration C_0, is recorded.

If the object is leaking, this concentration increases to C_1 and the signal S_1 is recorded at the time t_1. If the test were to be continued under the same conditions then, assuming a constant leakage rate, a signal corresponding to the continuing concentration increase would be observed at time t_2 (see dashed line in Figure A.2).

If, however, the calibration leak is opened at time t_1, the additional leak will give, at time t_2, a higher concentration (C_2) corresponding to the signal S_2.

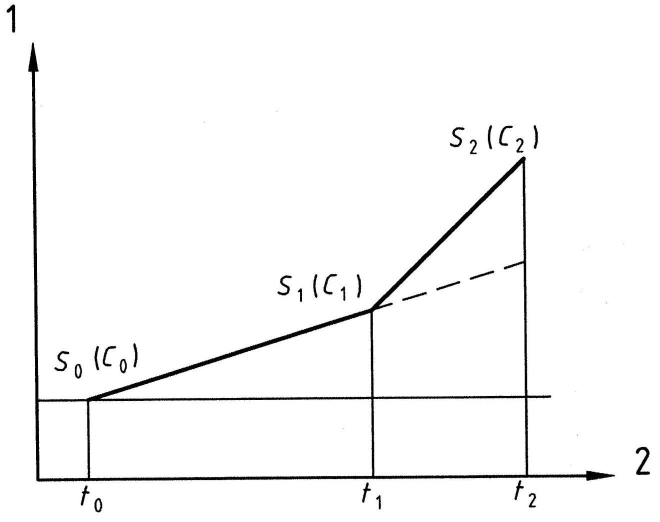
This concentration difference represents the contribution of the calibration leak during the time t_2 - t_1.



Key

1 reference leak
2 valve for leak
3 object
4 enclosure

Figure A.1 — Schematic diagram showing correction of a calibration leak supplied by tracer gas from the test object



Key

1 signal
2 time

Figure A.2 — Development of signal during the performance of an accumulation leak with and without a calibration leak

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