New European standard for the selection of a suitable method for leak detection and leak tightness testing

G Schröder*

Summary

*The new European standard **EN 1779***

"Leak testing: Criteria for method and technique selection"

for the first time provides a systematic classification of all leak testing methods within the scope of application. Moreover, the most important factors of influence and conditions in performing a leak test are addressed. In this way, it should be easier for users to select a suitable testing method.

In Annex A of the standard, all testing methods are systematically tabulated and each technique has been provided with an identification letter and a number. In addition to the respective minimum detectable leakage rate, important details on the measurement principle and the equipment required as well as, where applicable, restrictions on the test object are added.

1. Introduction – or: at last a standard!

With a few exceptions (e.g. in nuclear engineering), up to the present, there have been very few standards and codes in Europe in the field of leak testing and leak detection. One reason is the huge range of about 12 orders of magnitude for the determination of the leakage rate, which has to be coped with by measurement technology. Various testing possibilities and devices with in part different measurement ranges and measurement techniques are available for this purpose. It is therefore often not easy for the tester to select the right method for a given testing task.

The new EN 1779 standard approved in October 1999 now defines for the first time criteria for the selection of testing methods and techniques for leak testing.

The standard addresses the most important factors of influence in leak testing such as time dependence, influence of flow conditions (viscous laminar or molecular flow), influence of pressure and temperature as well as nature of gas and cleanliness of the object to be tested. Conversion factors are specified where required. Information on the range of leakage rates, on the test object design, the operating and testing conditions as well as the safety requirements for testing is also included.

A new feature is the systematic listing of (nearly) all leak testing methods contained in the Annex to the standard, which will be dealt with in more detail in section 5.

In addition to EN 1779, however, further important standards on the topic of leak testing have been published or are in preparation and should be noted. These new standards are listed at the end of this report.

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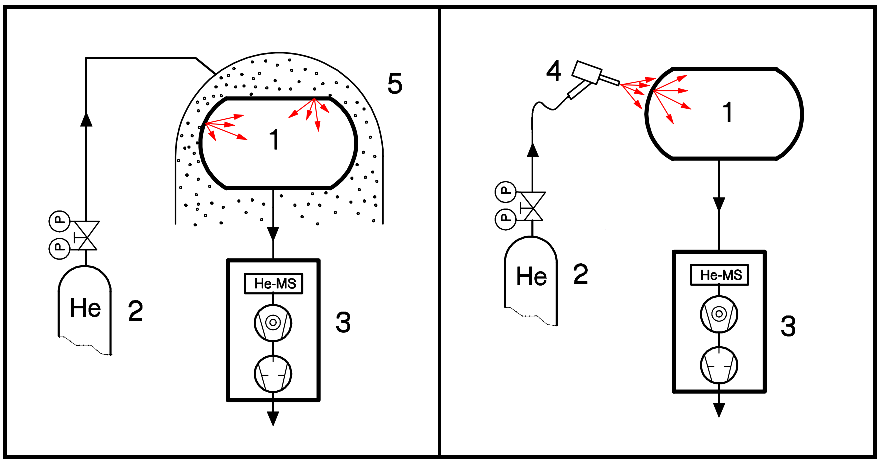
2. Knowledge required for selecting a testing method

The success (or failure) of a leak tightness test depends not only on the tester's diligence and quality of work, but also on the selection of a testing method suitable for the given task. Prior to the start of work, the testing conditions and testing goal should therefore be discussed and harmonized with the person ordering the test.

The following questions must be clarified for the selection of a testing method:

- How high is the permissible leakage rate specified for the test object?
  (Note: *Zero* leakage rate must not be specified according to the standard!)
- Testing should be performed at what testing pressure?
- What is the "testing direction" on the test object (pressure above or below the surrounding atmosphere)?
- Is the test object of sufficient mechanical stability to withstand the test pressure (overpressure or vacuum)?
- Is a *local* test (= detecting the location of leakage) or an *integral* test (= measurement of total leakage rate of the component) requested (Fig. 1)?
- Should the leakage rate level be determined?
- Are there any safety aspects to be complied with during testing?



1 Object to be tested
2 Tracer gas
3 Leak detector
4 Spray gun
5 Hood filled with tracer gas

Fig. 1: *Integral (left) and local test (right).*

Further requirements may result e.g. from the incompatibility of the material of the object to be tested with the test fluid or from the type and form of recording desired.

In selecting a suitable testing technique for a given task, however, apart from sufficient detection sensitivity, there are still other facts to be taken into consideration. The method should exhibit high testing reliability in order to avoid consequential damage and costs e.g. within the scope of product liability. Moreover, the in part not insignificant testing costs should also be taken into consideration in selecting the method. This does not only include the time required, but also the costs of existing or necessary testing devices and, if necessary, the type and quantity of the tracer gas used.

3. Applications and detection limits of the most important leak detection and leak tightness testing methods

Technical leak testing covers a huge range of more than 12 orders of magnitude for the leakage rate to be determined. Quite a number of different testing methods are available for this purpose. The most important techniques with their respective detection limits are compiled in Tab. 1.

Table 1: *Applications and detection limits of various leak detection and leak tightness testing methods under practical test conditions*

Overpressure methods

Detectable Leakage Rate [mbar·ℓ·s^{-1}] 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}	Measurement	Extent of test: local area	Extent of test: total area
Dye test	yes	yes	yes
Ultrasonic leak detection	no	yes	no
Bubble test (air / water)	yes	yes	yes
Bubble test (air / foaming solution)	no	yes	no
Pressure decay method	yes	no	yes
Leak tests with tracer gases (NH_3 etc.)	yes[1)]	yes	yes
Tracer gas method: helium sniffing test	yes[1)]	yes	yes

[1)] Quantification of the leakage rate only conditionally possible in sniffing tests

Vacuum methods

Detectable Leakage Rate [mbar·ℓ·s^{-1}] 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}	Measurement	Extent of test: local area	Extent of test: total area
Ultrasonic leak detection	no	yes	no
Pressure rise method	yes	no	yes
Tracer gases (halogen, NH_3 etc.)	yes	yes	yes
Helium leak test	yes	yes	yes
Residual gas analysis (with special device)	(yes)	(yes)	(no)

The detection limits specified in Tab. 1 should only be regarded as reference values. For some methods there are measuring or physical conditions limiting the measurement range. However, the detection limits are frequently also dependent on the ambient conditions under which the test is performed. In a test laboratory, as a rule, a more precise measurement will be possible than e.g. under aggravated conditions on a building site.

This may explain why the data in Tab. 1 concerning the detection limits can be different in the literature and in EN 1779 standard. If, for example, the detection limit of the bubble method is specified as $q_L \approx 10^{-6}$ mbar·ℓ·s^{-1} in a literature reference, this is not wrong from a physical point of view. From an economic perspective and concerning the performance of the test, this value is no longer justifiable. For a realistic bubble of 1 mm^3 to form, a measuring time of 10^3 s, i.e. approximately 17 min, would be required.

Of interest in this connection is also Fig. 2. It shows as an example the number of leaks detected (sorted by size) in a large number of test objects examined. As expected, a Gaussian distribution curve is obtained. Most leaks exhibited a leakage rate in the range of 10^{-4} mbar·ℓ·s^{-1}. From about 10^{-8} mbar·ℓ·s^{-1} upwards this curve is superimposed by other effects, such as gas permeation through sealing materials. However, what is important for us in this representation is that for the range in which the leaks are to be detected, i.e. from about 1 mbar·ℓ·s^{-1} to 10^{-8} mbar·ℓ·s^{-1}, not only *one* but *several* leak detection methods are available, which can be alternatively applied, as shown in Tab. 1.

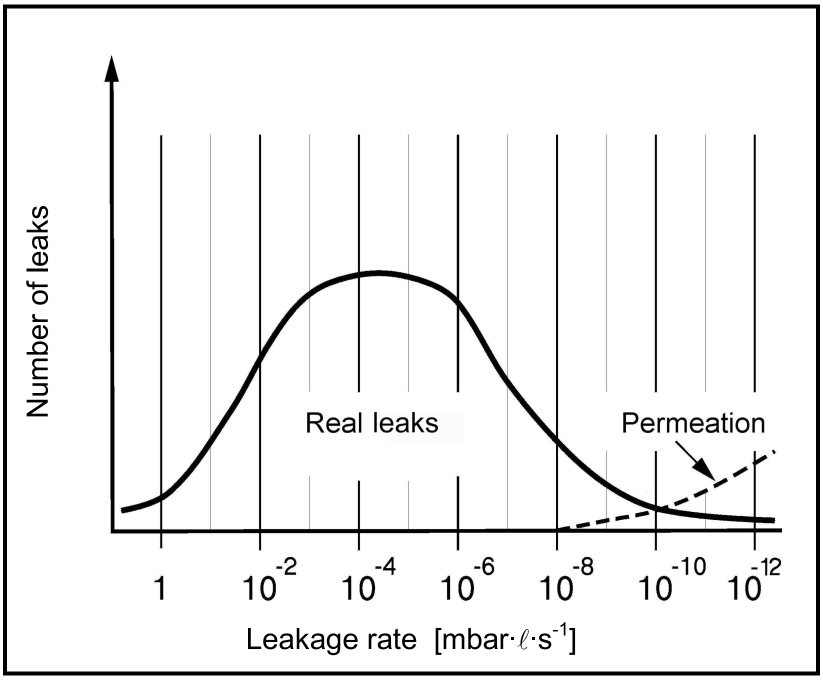


Fig. 2:
Distribution of leaks by size [Varian].

4. Classification of leak testing methods according to EN 1779

In the normative Annex A of standard EN 1779 various techniques and methods of leak detection and leak testing under the above conditions are systematically tabulated and each of them has been provided with an identification letter and a number.

For all methods important details concerning the measurement principle, nature of tracer gas and necessary equipment are additionally specified. As far as there are restrictions on the tracer gas or the measurement principle, these are also indicated. Moreover, it is specified whether the technique is suitable for "measurement" (= quantitative determination of the integral leakage rate) or for "location" (= local detection of leaks).

Table 2: *Leak Testing - Criteria for method and technique selection (from EN 1779).*

Flow direction	Extent of test	Applicability	Techniques
gas flow OUT of object	local area	location	B1, B2.2, B4, C3
		measurement	B2.1, B3, D3
	total area	location	C1, C2
		measurement	B5, D1, C1, B3, B6, D3, D4
gas flow INTO object	local area	location	A3
		measurement	A2, D3
	total area	location	
		measurement	A1, D2, D3, D4

Utilization of the table:
1) choose the appropriate flow direction for test;
2) define the extent of the investigation: total or local area;
3) define the aim of test: location or measurement;
4) choose the appropriate method (A to D, from the normative Annex A);
5) check any practical difficulties associated with the test.

NOTE: Some techniques used for location can also give an estimate of the leakage size, but they are not allowed to demonstrate the compliance with the specifications.

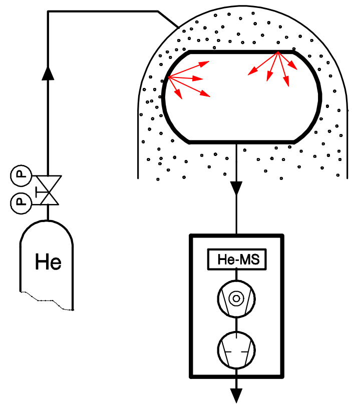
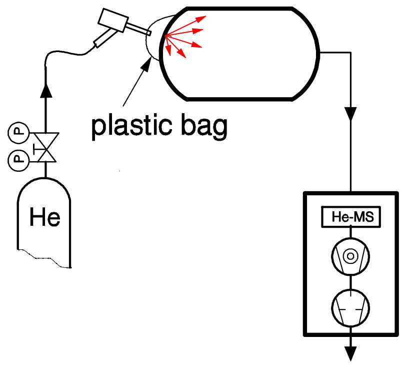
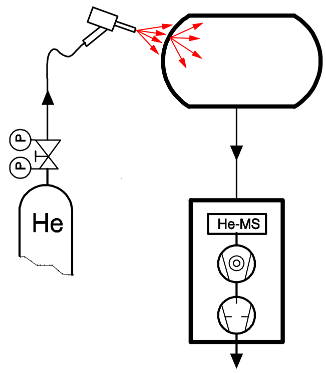
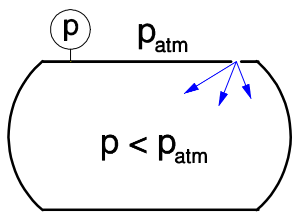
The minimum detectable leakage rate specified for each technique is a value normally achievable in tests under industrial conditions. According to the standard, the accuracy of the measurement may well be of the order of ± 50 %!

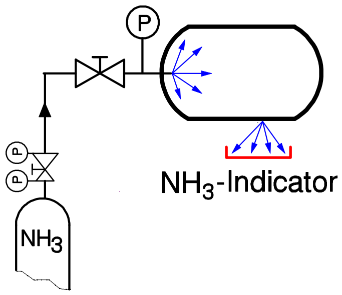
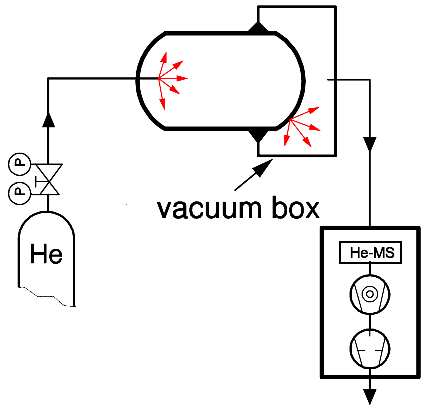
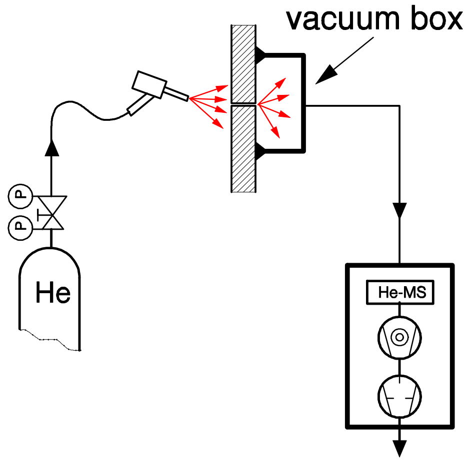
Incidentally, the unit in which the leakage rate is specified is $Pa \cdot m^3 \cdot s^{-1}$, which means a break with the generally known unit of $mbar \cdot \ell \cdot s^{-1}$ used in the past
(conversion: $1\ Pa \cdot m^3 \cdot s^{-1} = 10\ mbar \cdot \ell \cdot s^{-1}$).

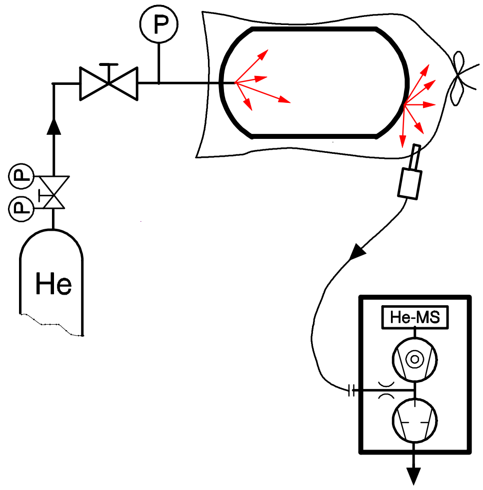
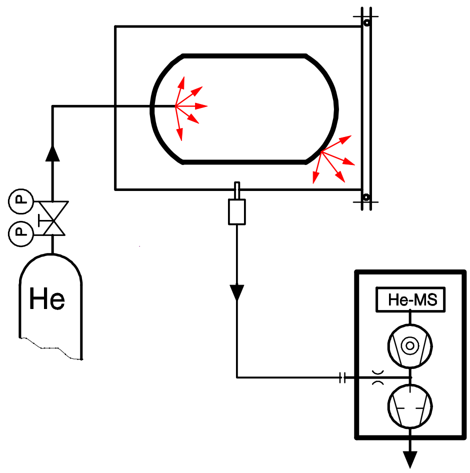
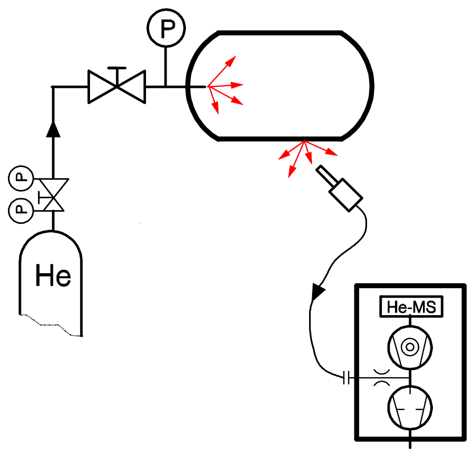
In the following, various testing possibilities are compiled as an excerpt from Annex A of the standard. Some important details concerning e.g. the equipment and general remarks on the individual techniques have been omitted. Reference is made here to the standard. The schematic diagrams are not contained in the standard; they were made by the author.

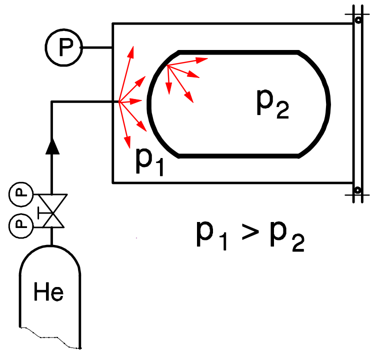
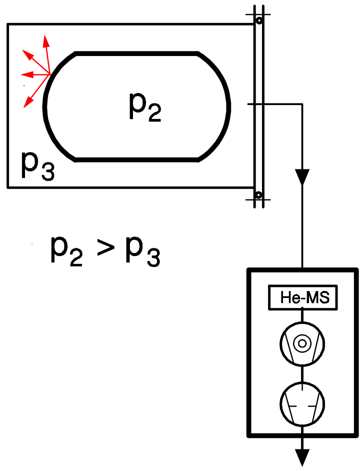
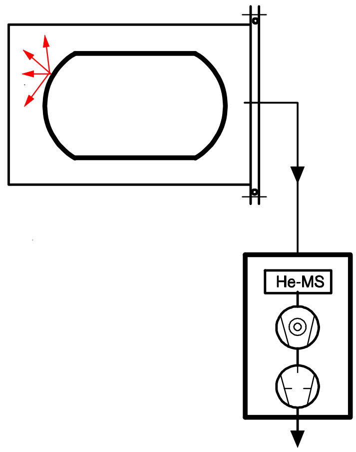
EN 1779 Annex A - normativ (excerpt)

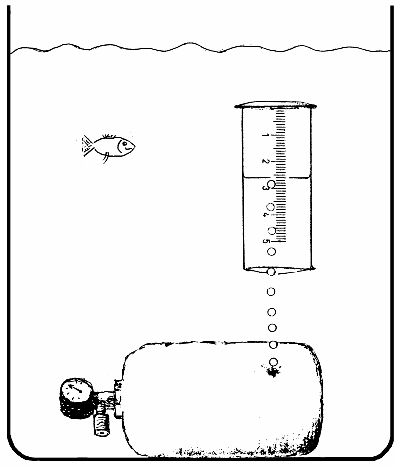
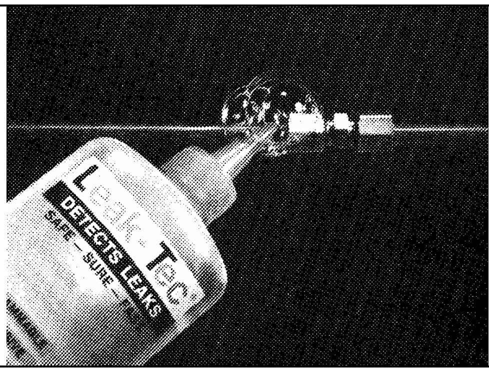
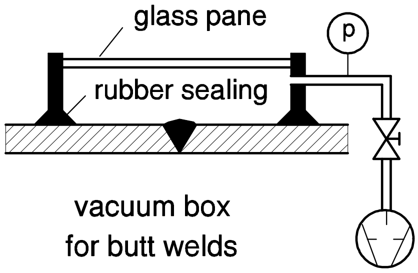
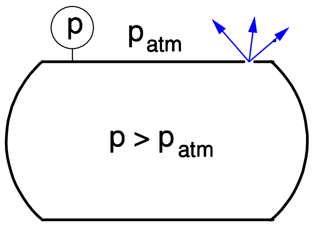
Specific features of leak testing methods – Tracer gas method

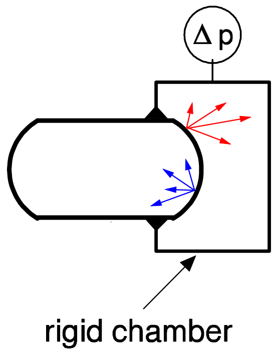
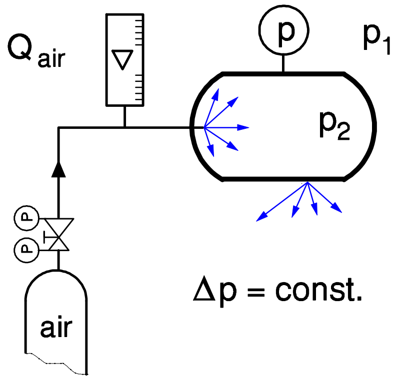
Gas flows INTO object			
A 1	**Vacuum technique** (total) *Test gas:* *usually helium*	Applicability: Measurement $q_{L\ min}$: 1) 10^{-10} $Pa \cdot m^3 \cdot s^{-1}$ (with helium)	
A 2	**Vacuum technique** (partial) *Test gas:* *usually helium*	Applicability: Measurement $q_{L\ min}$: 10^{-10} $Pa \cdot m^3 \cdot s^{-1}$ (with helium)	
A 3	**Vacuum technique** (local) *Test gas:* *usually helium*	Applicability: Location $q_{L\ min}$: 10^{-7} $Pa \cdot m^3 \cdot s^{-1}$	
D 2	**Pressure rise test** *Test gas:* *air*	Applicability: Measurement $q_{L\ min}$: 10^{-5} $Pa \cdot m^3 \cdot s^{-1}$ 2)	

Gas flows OUT of object			
B 1	**Chemical detection** with ammonia *Test gas:* *ammonia*	Applicability: Location $q_{L\ min}$: 10^{-7} $Pa \cdot m^3 \cdot s^{-1}$	
B 2.1	**Vacuum box,** using internal pressure of tracer gas *Test gas:* *tracer gas,* *usually helium*	Applicability: Measurement $q_{L\ min}$: 10^{-9} $Pa \cdot m^3 \cdot s^{-1}$	
B 2.2	**Vacuum box,** using spray gun on opposite side *Test gas:* *Tracer gas,* *usually helium*	Applicability: Location $q_{L\ min}$: 10^{-7} $Pa \cdot m^3 \cdot s^{-1}$	

Gas flows OUT of object (continued)			
B 3	**Pressure technique** by accumulation *Test gas: helium, halogen*	Applicability: Measurement $q_{L\ min}$: extract 10^{-7} $Pa{\cdot}m^3{\cdot}s^{-1}$ 2)	Test performed 1) with a gastight bag:  or 2) in a chamber: 
B 4	**Sniffing test** *Test gas: helium, halogen*	Applicability: Measurement $q_{L\ min}$: 10^{-7} $Pa{\cdot}m^3{\cdot}s^{-1}$	

Gas flows OUT of object (continued)			
B 5	**Pressurization – evacuation test** (“bombing test“) *Test gas:* *usually helium*	Applicability: Measurement $q_{L\ min}$: 10^{-9} to 10^{-6} $Pa{\cdot}m^3{\cdot}s^{-1}$	<u>Step 1:</u>  <u>Step 2:</u> 
B 6	**Sealed objects** by external vacuum technique (extern) *Test gas:* *helium, halogen*	Applicability: Measurement $q_{L\ min}$: 10^{-9} $Pa{\cdot}m^3{\cdot}s^{-1}$	

Gas flows OUT of object (continued)			
C 1	**Bubble test** (immersion) *Test gas:* *usually air*	Applicability: Location $q_{L\ min}$: 10^{-4} $Pa{\cdot}m^3{\cdot}s^{-1}$	
C 2	**Bubble test** (liquid application) *Test gas:* *usually air*	Applicability: Location $q_{L\ min}$: 10^{-4} $Pa{\cdot}m^3{\cdot}s^{-1}$	
C 3	**Bubble test** with vacuum box *Test gas:* *usually air*	Applicability: Location $q_{L\ min}$: 10^{-3} $Pa{\cdot}m^3{\cdot}s^{-1}$	
D 1	**Pressure decay test** *Test gas:* *air or other* *non- condensable gas*	Applicability: Measurement $q_{L\ min}$: 10^{-5} $Pa{\cdot}m^3{\cdot}s^{-1}$ 2)	

Gas flows INTO or OUT of object (application with overpressure or vacuum)			
D 3	**Pressure change test** (bell pressure change) (with overpressure or vacuum) *Test gas:* *air or other non-condensable gas*	Applicability: Measurement $q_{L\ min}$: 10^{-6} $Pa \cdot m^3 \cdot s^{-1}$ 2)	
D 4	**Flow measurement** *Test gas:* *air*	Applicability: Measurement $q_{L\ min}$: 10^{-4} $Pa \cdot m^3 \cdot s^{-1}$	

<u>*Note:*</u>

1) $q_{L\ min}$ = minimum detectable leakage. Values usually obtained under industrial conditions.
2) Restrictions on minimum detectable leakage rate see EN 1779.
3) He-MS = helium mass spectrometer (helium leak detector).

Leak detection using hydrostatic tests, ultrasonic or electromagnetic methods is not included in this standard.

Conversion factor: $1\ Pa \cdot m^3 \cdot s^{-1} = 10\ mbar \cdot \ell \cdot s^{-1}$

The schematic diagrams are *not* part of the standard, they were made by the author.

Figures and layout:

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Note: In April 2001 a similar report was published in the DGZfP-journal *ZfP-Zeitung*, No. 74, pp. 31 – 39 and in December 2001 in the Britsh Journal *insight,* Vol. 43, No. 12, pp. 797 - 803.

Status of European standardization for leak tightness testing

(as of February 2011)

Up to the present, the following documents have been published as **European standards**.

Number	German title of standard	Remarks
EN 1330-8	Non-destructive testing – Terminology Part 8: Terms used in leak tightness testing *Zerstörungsfreie Prüfung - Terminologie –* *Teil 8: Begriffe für die Dichtheitsprüfung*	trilingual
EN 1518	Non-destructive testing – Leak Testing Characterization of mass spectrometer leak detectors *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Charakterisierung von* *massenspektrometrischen Leckdetektoren*	following ISO 3530
EN 1779	Non-destructive testing – Leak Testing Criteria for method and technique selection *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Kriterien zur Auswahl von Prüfmethoden und Verfahren*	Harmonized Supporting Standard
EN 1593	Non-destructive testing – Leak Testing Bubble emission techniques *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Blasenprüfverfahren*	Harmonized Supporting Standard
EN 13184	Non-destructive testing – Leak Testing Pressure change method *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Druckänderungsverfahren*	Harmonized Supporting Standard
EN 13185	Non-destructive testing – Leak Testing Tracer gas method *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Prüfgasverfahren*	Harmonized Supporting Standard
EN 13192	Non-destructive testing – Leak Testing Calibration of gaseous reference leaks *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Kalibrierung von Referenzlecks für Gase*	Harmonized Supporting Standard
EN 13625	Non-destructive testing – Leak Testing Instructions for the selection of leak testing devices *Zerstörungsfreie Prüfung - Dichtheitsprüfung –* *Anleitung zur Auswahl von Dichtheitsprüfgeräten*	Harmonized Supporting Standard

Source: Werner Große Bley, Inficon GmbH, Cologne, Germany

Further applications for standardization in the field of leak tightness testing are not available at present.