Important regulations for leak detection and tightness control

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Common standards and high quality levels for the leak detection and tightness control of materials can only be reached by internationally valid norms. In order to meet the increasingly stricter demands set on tightness control, many of the existing norms have been updated within the last years. These updates especially affect the regulations for the calibration of test leaks, which have been significantly expanded. Moreover, also the European regulations were updated and reconciled with ISO regulations (ISO = International Standard Organization). ISO closely collaborates with CEN (Comité Européen de Normalisation, European Committee for Standardization). The transfer of ISO regulations into national regulations is voluntary, whereas the transfer of European regulations into national regulations is mandatory.

The universal acronym "ISO" originates in the Greek word isos meaning "equal".

Leak detection under vacuum: relevant norms

DIN EN ISO 20484:2017-07 – Vocabulary [2]
ISO 20848:2017 is a good example for a direct transfer of an ISO regulation into an European regulation. CEN adopted the ISO norm without any changes or amendments and implemented it in the German-speaking countries as DIN EN ISO 20484:2017-07. It replaces the predecessor norm DIN EN 1330-8:1998-07 [3], in which the technical vocabulary for leak detection is summarized. Several definitions from the field of pressure and vacuum measurement have been dropped. Moreover, the editor inserted some updates and revised definitions. The regulation is available in several languages and used in practice for the correct wording in work instructions, tenders, and comparable documents or the respective translations.

DIN EN 1779:1999-10 with Corrigenda 2005-02 – Non-destructive Testing – Leak testing: criteria for the method and technique selection [4], [5]
In this norm, the various methods of leak testing are classified into three criteria: flow direction, extent of test and applicability for leak localization (qualitative) or pass/fail decision (quantitative measurement). Table 1 displays the respective criteria and method acronyms.

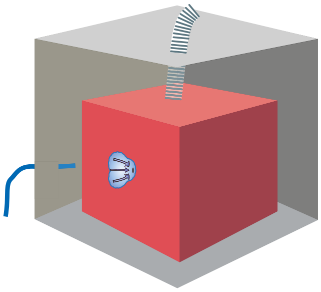
In February 2005, corrections were made in Annex B, a conversion table for leakage rate units [5].

Moreover, the regulation contains a guideline for the conversion of the different leak rate units in various industrial segments. It also details the dependency of tightness – expressed as leakage rate for a specific gas – from the environmental parameters pressure and temperature. Especially this guideline is very precious for the practical users.

The norm moreover provides practical examples and relevant formulas for the conversion of leak rates under laminar-viscous and molecular flow conditions in the leak channel for the environmental parameters pressure, temperature, and gas types. The regulation also indicates the minimum detectable leak rates for each method. This indication allows practical users to estimate whether the detection limits specified by the manufacturer can be realized in industrial practice. However, due to the technical advances in the design and production of equipment, some of these indications are outdated. In addition, there are references to withdrawn regulations still included, such as DIN EN 1330-8 [3] or DIN EN 473 [25], for example. Therefore, DIN EN 1779 is currently being reviewed. No graphs or diagrams are included in the regulation to visualize the respective techniques. A more vivid presentation of the different test methods can be found, for example, in a commentary on the regulation [6] or in directive DP 1 of the German Society for Non-Destructive Testing (DGZfP) [7]. DIN EN 1779 combines various methods including tracer gas, pressure decay and pressure rise, flow, bubble testing, etc. Another relevant norm for vacuum technicians is ISO 20485:2017-11 , which focuses on tracer gas test methods.

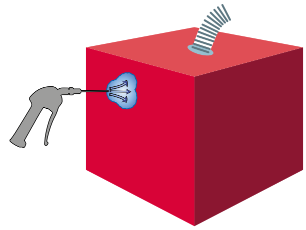
Flow direction	Extent of test	Applicability	Techniques
Gas flow OUT of object	Local area	Location	B1, B2.2, B4, C3
		Measurement	B2.1, B3, D3
	Total area	Location	C1, C2
		Measurement	B5, D1, C1, B3, B6, D3, D4
Gas flow INTO object	Local area	Location	A3
		Measurement	A2, D3
	Total area	Location	
		Measurement	A1, D2, D3, D4

Tabelle 1: Kriterien zur Auswahl von Methoden und Verfahren nach DIN EN 1779



Integral test of enclosed parts under vacuum

Vacuum technique (total)
Method A.1



Vacuum test: Spraying test

Vacuum technique (local)
Method A.3

Figure 1: Group A methods according to ISO 20485: tracer gas flowing into object

ISO 20485:2017-11 – Non-destructive testing – Leak testing – Tracer gas method [8]

Editorial changes, the omission of information on personnel qualification as well as the integration of carrier gas techniques are the most important updates included in this norm. The predecessor regulation DIN EN 13185:2001-07 [9] was withdrawn in May 2018. ISO 20485:2017-11 defines the demands set on a test report. Moreover, it describes tracer gas methods for gas flow into an object. These are the most important methods for a vacuum technician and are shown schematically in figure 1:

A variant is method A.2 (vacuum technique (partial)), where only a part of the object is enclosed by the bag filled with tracer gas.

Moreover, the norm presents methods where tracer gas escapes from the interior of the object to the outside. In addition to the main methods shown in figure 2, the regulation cites:

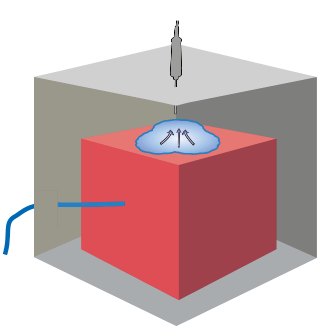
- Method B.1 – Chemical detection with ammonia
  This method is mainly used in refrigeration plants, which are operated with ammonia.

- Method B.2.1 – Vacuum box, using internal pressure of tracer gas
  This method is mainly used for very large objects with a vacuum box applied on the outer surface.

- Method B.2.2 – Vacuum box, using spray gun on opposite side
  This method is in use with joined flat metal plates. A vacuum box is applied on one side. On the other side, helium is sprayed.

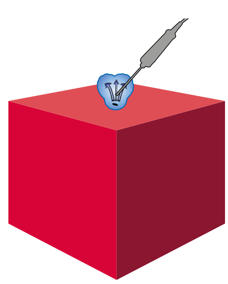
- Method B.5 – Bombing test
  The bombing test technique is also known as pressurization-evacuation test. It is used to test small, hermetically sealed objects. In a first step, the objects are exposed to a helium atmosphere at high pressure. If leaks are present, helium will penetrate into the unit under test during this phase. In a second step, the objects are tested in a test chamber just as in method B. 6.

- Method B.7 – Carrier gas technique
  This method has been newly included into the regulation. Here, the test object is filled with tracer gas and surrounded by a bell jar or flexible compartment which is purged with a tracer gas-free carrier gas. The carrier gas transports tracer gas escaping from the object to a downstream sensor. In most cases, this is the sniffer probe of a helium leak detector.
  This method uses simple leak detection equipment as a variant of the sniffing test. It is applied, for example, to test valve seals. In this application, the flanges of the valve can be taped in order to form a simple enclosure. The volume between seal and tape is purged with a carrier gas so that a leak test can be performed without dismantling the valve assembly.



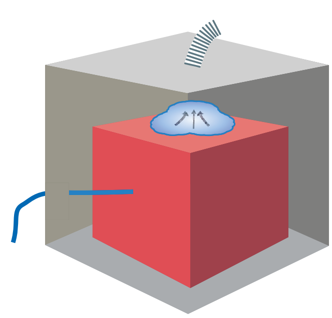
Sniffing test: Integral test at atmospheric pressure

Pressure technique by accumulation Method B.3



Sniffing test

Sniffing test
Method B.4



Integral vacuum test

Sealed objects by external vacuum technique
Method B.6

Figure 2: Group B methods according to ISO 20485, gas flow out of object

Figure 3: Non-destructive leak detection is vital especially in the serial production of the automotive industry.

The technique can also be carried out in another variant which is not explicitly mentioned in the regulation. In this version, the object is purged with a carrier gas at low pressures (pressure range roughly 0.1 … 25 mbar) and tracer gas is applied to the outside of the object. This method is very useful for testing objects that have a high flow resistance in high vacuum such as gas supply lines or tubes in a tubular heat exchanger.

ISO 20485 describes the needed devices and equipment. Moreover, it refers to the recently updated regulations for equipment and calibration.

ISO 20486:2017-12 – Non-destructive testing — Leak testing — Calibration of reference leaks for gases [10]
This norm is the successor of regulation DIN EN 13192 [11]. It describes the calibration of test leaks. In the latest edition, various definitions were added and the environmental conditions for reference leak rates were defined. Moreover, the application range of the regulation is graphically displayed and recommendations on which calibration method should be applied for the respective range of leak rates are included. Methods A and B were already part of the previous regulation and describe the calibration by comparison with a reference leak – covering either one or two reference leaks in vacuum or for sniffing applications. Also Method C was already considered in the previous norm. It describes a volumetric calibration. Method D was added for leak rates between 0,2 Pa m3/s and 8 Pa m3/s. It describes calibration by water displacement. For the calibration of very large leaks in the range between 2,000 sccm and 100,000 sccm, method E, calibration by gas meter, was included. Method F describes calibration by pressure change in a known volume for the classical sensitivity range of a helium leak detector. With Method G, calibration by volume change at constant pressure is described. For vacuum technology, methods for large leak rates are less relevant while they are highly important in industrial leak testing.

DIN EN 1518:1998-06 – Non-destructive testing — Leak testing — Characterization of mass spectrometer leak detectors [12]
DIN EN 1518 provides the essential tools for leak testing personnel. It describes mass spectrometer type leak detectors, defines the needed accessories for important techniques and presents methods for the measurement of the lowest detectable leak rate as well as the lowest detectable concentration. Moreover, it defines the reference conditions and the content of a test report.

DIN EN 13625:2002-03 – Non-destructive testing — Leak testing — Guide to the selection of instrumentation for the measurement of gas leakage [13]
DIN EN 13625 contains a guideline for the selection of test equipment, the respective accessories as well as the execution of various techniques. Tracer gas methods according to group A (gas flow into the object) and B (gas flow out of the object) as well as bubble emission techniques and pressure change methods are considered here.

Regulations for non-vacuum technology leak testing
For leak testing under vacuum, classical helium leak detectors are used for testing vacuum vessels or gas lines. These devices are equipped with mass spectrometer detectors, which operate in high vacuum. The know-how regarding the equipment and possible applications can foremost be found at the side of the equipment manufacturers. The use of tightness control in industrial applications – in most cases production line integrated – sets additional demands on the equipment and the quantification of test results from helium leak detectors as well as many other detector types and techniques. Examples for these techniques are bubble testing or pressure change and flow measurement.

Figure 4: Calibration station from Pfeiffer Vacuum

Title old	Title new
DIN EN 1330-8:1998-07 Non-destructive testing – Terminology – Part 8: Terms of leak testing; trilingual version EN 1330-8:1998 (withdrawn)	**DIN EN ISO 20484:2017-07** Non-destructive testing – Leak testing – Vocabulary (ISO 20484:2017); German version ISO 20484:2017
DIN EN 1779:1999-10 Non-destructive Testing – Leak testing: criteria for the method and technique selection; German version EN 1779:1999 **Corrigenda 2005-02** Corrigenda to DIN EN 1779:1999-10	Still valid, currently under revision For further information please see [6], [7].
DIN EN 13185:2001-07 Non-destructive testing – Leak testing – Tracer gas method; German version EN 13185:2001 Withdrawal intended, to be replaced by DIN EN ISO 20485; release date: 2018-05	**ISO 20485:2017-11** Non-destructive testing – Leak testing – Tracer gas method [8]
DIN EN 13192:2002-03 Non-destructive testing — Leak testing — Calibration of reference leaks for gases; German version EN 13192:2001	**ISO 20486:2017-12** Non-destructive testing — Leak testing — Calibration of reference leaks for gases **DIN EN ISO 20486:2018-05** Non-destructive testing — Leak testing — Calibration of reference leaks for gases (ISO 20486:2017); German version EN ISO 20486:2018
DIN EN 13625:2002-03 Non-destructive testing — Leak testing — Guide to the selection of instrumentation for the measurement of gas leakage; German version EN 13625:2001	Still valid
DIN EN 1518:1998-06 Non-destructive testing — Leak testing — Characterization of mass spectrometer leak detectors; German version EN 1518:1998	Still valid
DIN EN 1593:1999-11 Non-destructive testing — Leak testing — Bubble emission techniques; German version EN 1593:1999	Still valid
DIN EN 13184:2001-07 Non-destructive testing — Leak testing — Pressure change method; German version EN 13184:2001	Still valid

Table 2: Comparison of current regulations and their predecessors

DIN EN 1593:1999-11 – Non-destructive testing — Leak testing — Bubble emission techniques; German version EN 1593:1999 [14]

Bubble test methods are described in DIN EN 1593:1999-11. The norm also covers the immersion of a test object under gas overpressure into a liquid as well as the application of a test fluid on the object. Integration of ultrasonic bubble testing into the regulation has been proposed but not yet implemented. In general, bubble emission techniques are mainly used for the localization of leaks.

DIN EN 13184:2001-07 – Non-destructive testing — Leak testing — Pressure change method; German version EN 13184:2001 [15]

Leak testing by pressure change mainly serves the quantitative measurement of a leak rate as a basis for a pass/fail decision. In industrial serial production such as in the automotive industry, these methods are highly important.
In the vacuum industry, these measurement methods are, for example, used after the maintenance of coating systems in order to define an integral leak check. This check serves as a start/stop criterion for the release of a vacuum process. Here, it is important that also gas flows caused by permeation and mainly desorption are considered. In case the allowed pressure rise is only slightly exceeded, pressure swing cycling can reduce desorption gas load.

Summary

A summary of currently valid regulations can always be only a snapshot. Table 2 gives an overview of the current editions of relevant regulations for leak detections and tightness control.

In addition, there are many regulations which are applied in specific fields of industry. Examples are:

- Environmental tests for electronic devices [16]
- Leak detection of refrigerating systems and heat pumps [17], [18]
- Leak detection of industrial valves [19], [20]
- Fugitive emission control [21], [22], [23], [24]

Outlook

The technical and economic significance of leak detection and integrity control is crucial. Incidents such as the explosion of the space shuttle "Challenger" and the largest recall action in the history of automotive industry are both related to tightness problems. Still, leak detection is ignored in the majority of university classes and company-based trainings. Therefore, it is highly important to implement and correctly apply the relevant information and regulations by skilled personnel. Pfeiffer Vacuum offers the matching trainings to reach this qualification. Moreover, accredited training centers such as the German Society for Non-Destructive Testing provide certified education with its LT1, LT2, and LT3 trainings according to DIN EN ISO 9712 [26], [27]. Moreover, there will be certified educations for operators which are currently being prepared for many test methods and techniques.

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