



TIPS AND TRICKS FROM THE EXPERTS

Leak detection – principles, use, methods

Global warming, climate change, the greenhouse effect - our modern industrialized lifestyle has a tremendous impact on the environment. As a result, environmental regulations for industrial companies are getting tougher all the time: Emissions of harmful gases and liquids need to be curbed, and the harmful impact of refrigerants, waste gases and propellants must be minimized. In view of this, industry requirements specifying the leak tightness of components have steadily grown during recent years.

Leak tightness testing – known as leak detection - is indispensable for meeting leak tightness specifications, as companies can only achieve this by using a wide range of leak detection methods. Various methods are available (table 1) to meet the different leak tightness specifications.

It is enough in many cases to conduct a qualitative test that merely shows the existence of a leak. However, it is also necessary to assess the leak rate if specific quality requirements and customers' specifications have to be met. Against this background, most of the well-known leak detection methods can be ruled out – as the last column of table 1 shows.

The only methods that are suitable to provide quantitative verification of leaks are leak detection methods using sniffer and tracer gases (with helium, for example) and pressure drop and pressure rise methods. The detection limit in the pressure drop and pressure rise method, however, is limited to values greater than $1 \cdot 10^{-3} \text{ Pa m}^3/\text{s}$. So, for stricter leak rate specifications, sniffer or integral leak detectors are the only possible options. Most integral leak detectors on the market have what

Method	Tracer gas	Smallest detectable leak rate		Pressure range	Quantitative measurement
		Pa·m ³ /s	g/a R134a		
Foaming liquids	Air and other	10 ⁻³	7 · 10 ⁻¹	Overpressure	No
Ultrasonic microphone	Air and other	10 ⁻¹	70	Overpressure	No
Thermal conductivity leak detector	Other gases apart from air	10 ⁻² – 10 ⁻³	10 ⁻¹ – 7	Overpressure and vacuum	No
Halogen leak detection	Substances containing halogen	10 ⁻⁴ (10 ⁻⁵)	10 ⁻¹ (10 ⁻¹)	Overpressure (vacuum)	With restrictions
Multipurpose sniffer leak detectors	Refrigerant helium and other gases	10 ⁻⁴	10 ⁻¹	Overpressure	Yes
Helium leak detection	Helium	10 ⁻¹¹	7 · 10 ⁻⁹	Vacuum	Yes
		10 ⁻⁶	7 · 10 ⁻⁴	Overpressure	
Bubble test	Air and other	10 ⁻²	7	Overpressure	No
Water pressure Test	Water	10 ⁻¹	70	Overpressure	No
Pressure drop test	Air and other	10 ⁻³	7 · 10 ⁻¹	Overpressure	Yes
Pressure rise test	Air	10 ⁻³	7 · 10 ⁻¹	Vacuum	Yes

Table 1: Various different leak detection methods with their detection limits and corresponding emission levels in gram/year, here for refrigerant R 134a, as an example.

is called a sniffer probe, which gives the option of using either the vacuum method or the sniffer method.

Definition of leak rate

The unit used to define a leak rate in Europe is Pa m³/s.

To illustrate this:

The leak rate is 1 Pa m³/s if the pressure in an evacuated tank with a volume of 1 liter increases by 1 hPa in the space of 1 second or, in the case of overpressure in the tank, if the pressure falls by 1 hPa in 1 second.

Helium leak detector now established as a method

In view of increasingly restrictive regulations to prevent emissions, leak tightness requirements for gas or fluid-carrying parts have also tightened to halt unacceptable environmental impacts, such as from escaping fuels, hydraulic or transmission oils or refrigerants. Depending on the leak tightness requirement, there are various different test methods that can be used, and their detection limits are indicated in table 1. Examples of these requirements could include:

- The maximum admissible leak rate
- The cycle time
- The geometry and size of the test specimen

In recent years, leak detection using helium as the tracer gas has particularly established itself as a method for detecting leaks. Unlike other detection methods, this process can

quantify and localize even the smallest leaks. This allows leaks to be rectified quickly. In addition, geometries can be changed, and improvements made to production methods and workflows. The resulting benefits are improved quality, higher yields, and savings in production and testing costs. Most of the tracer gas leak detectors available today can be used as sniffer and vacuum leak detectors.

Why use helium as the tracer gas?

The natural concentration of helium in the air amounts to only about 5 ppm. As a result, the proportion of helium in the background during sniffer testing is so low that it is still possible to take highly sensitive readings. Advantages at a glance of helium as tracer gas

- Helium is a very small molecule that ingresses through any gaps, hairpin cracks, etc.
- The use of helium makes it possible to cover a very wide sensitivity spectrum of 10⁻¹–10⁻¹² Pa m³/s
- Mass spectrometry is a very sensitive and highly selective detection method
- Fast measuring cycles and high test specimen throughput minimize testing costs due to the fast response times obtained
- Helium is an inert gas and does not react chemically with other substances; it is harmless in use, environmentally friendly and is approved as an additive for food and pharmaceuticals
- Precise, standard-compliant and reproducible leak detection

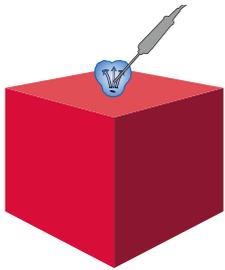


Figure 1: Localizing sniffer test method

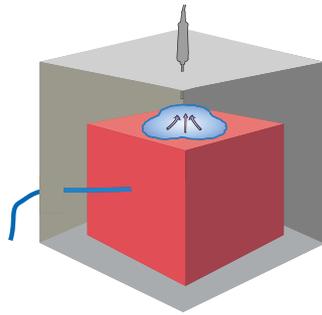


Figure 2: Integral sniffer test method (accumulation test)

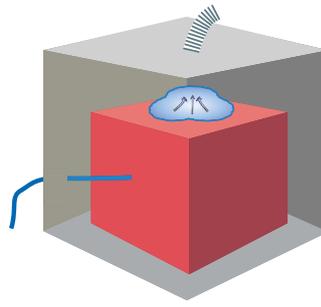


Figure 3: Integral vacuum method (test specimen filled with tracer gas)

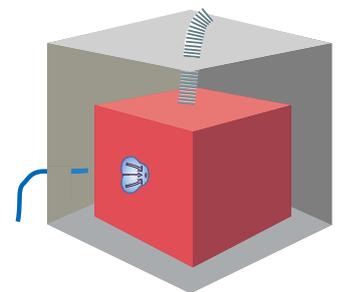


Figure 4: Integral vacuum method (test chamber filled with tracer gas)

Sniffer methods at a glance

a) Localizing method

In the localizing sniffer method, the test specimen is pressurized with a gas mixture containing helium. The test specimen is then searched from the outside for leaks using a sniffer probe (see figure 1). If a leak is detected, the leak detector indicates this with an optical and acoustic signal. The leak can then be marked and repaired.

b) Integral method

In the integral method (including accumulation testing or the sniffer method in an enclosing shell, see figure 2), the test specimen is exposed to helium overpressure in a test chamber. At atmospheric pressure, the sniffer probe measures the rise in the concentration of helium in the enclosed volume around the test specimen, and tests it for any leaks. It is not possible to localize leaks, however, using this method.

Sniffer methods can be used in accordance with DIN EN 1779 up to a leak rate greater than $10^{-7} \text{ Pa m}^3 \text{ s}^{-1}$ (10^{-6} mbar l/s). New instrument technologies extend this range up to $5 \cdot 10^{-10} \text{ Pa m}^3 \text{ s}^{-1}$ ($5 \cdot 10^{-9} \text{ mbar l/s}$).

Vacuum methods at a glance

c) Integral vacuum method

(test specimen filled with tracer gas)

In this method, the test specimen is placed in a vacuum chamber. This is then subsequently evacuated. Compared to the pressure in the chamber, the test specimen itself is filled with tracer gas at an overpressure (see figure 3). This allows even the smallest leaks to be detected in vacuum mode. This method is used in industrial production to ensure that the prescribed leak tightness directives are met. It can be used with test specimens of any size. Under certain circumstances, depending on the cycle time and detection sensitivity specified, the test need not be conducted with 100% helium. It may be possible in this way to make savings by using lower concentrations of helium in the tracer gas. It must be remembered, however, that a lower concentration of tracer gas can result in longer testing times and lower signal intensity.

d) Integral vacuum method

(test chamber filled with tracer gas)

This method is used with test specimens which are exposed to less than atmospheric pressure in use of their actual application. This is the case, for example, with vacuum chambers. The test specimen is evacuated and subjected to a defined concentration of the tracer gas at a defined tracer gas pressure in a chamber (see figure 4). As soon as tracer gas ingresses into the test specimen, the mass spectrometer in the leak detector detects the helium and indicates the leak rate with an optical signal. The leak detector indicates with an acoustic signal or an optical indicator (red/green) that a defined maximum limit has been exceeded.

Test data logging

All test data for the test specimens can be transmitted, by consecutive number, to a main computer through an RS-485 interface, which enables a verification document for the test to be issued at any time.

Determining a suitable test method in individual cases

The best test method for the application should be determined in each case for the specific requirements and parameters. The test methods described can be used alone or as a combination of a vacuum and sniffer method. With its broad portfolio of leak detectors, Pfeiffer Vacuum has the ideal solution for every application - including portable leak detectors for use on site and high-performance leak detectors or leak detectors for multipurpose use. Our experts also design custom leak detection systems to meet specific customer requirements.

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Pfeiffer Vacuum GmbH
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