LEAK TESTING

Leading leak test and leak detection solutions for your integrity challenges
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Why leak testing?

Leak testing plays an important part for our everyday safety, environmental protection as well as for the reliability of production processes and products we use daily.

There are numerous applications for leak testing. One of the most common applications is in the automotive industry. Fuel, brake, cooling and airbag systems are just some examples which rely on proper leak testing. Also, applications in the refrigeration and air conditioning industry, the medical and pharmaceutical industry, as well as the semiconductor industry and research applications are just a few further examples with a high demand in regards to leak testing.

Typical challenges

As important as it is, it is challenging to determine the perfect leak test process for a particular application. The process begins with the definition of the required tightness, respectively leak rate. This gets especially complex due to the different units that are used in this context. The next challenge is then to define the right test method and procedure. A large number of different options are available with different characteristics in regards to sensitivity, accuracy, user-friendliness and cost of ownership.

Application examples

- Mobile camera
- Blister packs
- Air cooling
- Fuel tank
Pfeiffer Vacuum

Pfeiffer Vacuum is one of the world’s leading providers of vacuum and testing solutions with over 50 years of leak detection experience. The product portfolio includes: vacuum pumps, measurement and analysis devices, components as well as vacuum chambers and high performance detection systems.

Our know-how

Pfeiffer Vacuum unites the leading pioneers in the field of leak detection. In 1966 our colleagues in France invented the first commercial helium leak detector. Only two years later Pfeiffer Vacuum in Germany introduced the counter flow principle which until today still is the basis for nearly all modern tracer gas leak detectors. Recently we completed this strong team with the air leak testing experts from ATC (Advanced Test Concepts). With this combined expertise and broad portfolio, Pfeiffer Vacuum is your perfect partner in regards to all leak testing challenges.

Solution partner

For us it is not only about selling products but providing complete solutions. That means we offer you technical assistance over the entire process. This includes feasibility tests and test implementation. Customers also benefit from our complete product portfolio outside of leak detection that includes vacuum pumps, chambers and measurement instruments. Furthermore, we maintain a partner network to support you in regard to fully automated solutions.

Pfeiffer Vacuum core strengths in leak detection

Providing one-stop shop for all your leak testing needs:

- Help you to define your leak tightness requirements
- Providing engineering support to select the optimal and safest leak test solution for your application
- Broad range of solutions – tracer gas and air leak detection with dedicated solutions for sealed products, as well as calibration services and complete vacuum portfolio with pumps, chambers and instruments
- Complete integrated solution, including consulting and partner network for automated systems
- And much more…

We at Pfeiffer Vacuum are committed to your success and to reduce your risks during the leak test selection and operation.
LEAK DETECTION CHALLENGES

From defining the requirements over selecting the right method to implementing the testing process

Leak rate requirements

The definition of the right leak testing process most often start with the definition of the needed tightness requirement. This is often described in g/y (US: ounces / year), orifice leak size in μm or more precisely equivalent channel. Other typical units are the SI unit Pa·m³/s or mbar·l/s. The table besides gives an indication in regard to different leak sizes described in mbar·l/s, leak diameter and the time it takes for the escaping gas to create a bubble under water. Those guideline values are then correlated to typical requirements as “water tight”, “bacteria tight” and “gas tight”.

Typical leak test methods

The table on the right gives you an overview of different leak testing methods and some of the most typical criteria concerning the selection of a test method. Certainly, the desired sensitivity is a key criterion. Additional key questions are: if the test object can be put under pressure or vacuum, which tracer gas can or should be used, if a quantitative result is desired and if a localization of the leak is required are important for the appropriate selection.

Another important criterion that also should be considered is the targeted test or cycle time. Thereby, the whole process including stabilization and, if applicable, also drying times should be considered. Furthermore, test methods are divided into destructive and non-destructive methods. Here the value of the object or the content of the packaging should be considered when choosing a method.

Pfeiffer Vacuum leak testing portfolio

Pfeiffer Vacuum has the most extensive leak testing portfolio in the market. The available test methods are thereby featured by quality, accuracy and user-friendliness and offer top performance with low cycle times.

Micro-Flow / Mass Extraction

Fast and reliable leak testing for packages and electronics as well as industrial and medical applications

Emission spectroscopy

Integrity testing for high demanding pharmaceutical packages and advanced sealed devices

Tracer gas

Highest sensitivity and leak detection for high end applications as automotive, medical & semiconductor industry
### Overview of leak test methods

<table>
<thead>
<tr>
<th>Method / Detector</th>
<th>Tracer gas</th>
<th>Tested object under overpressure</th>
<th>Tested object under vacuum</th>
<th>Quantitative test</th>
<th>mbar l/s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water tight</td>
<td>Bacteria tight</td>
<td>Virus tight</td>
<td>Gas tight</td>
</tr>
<tr>
<td>Leak diameter</td>
<td>100 µm</td>
<td>30 µm</td>
<td>10 µm</td>
<td>3 µm</td>
<td>0.8 µm</td>
</tr>
<tr>
<td>Escape time of a</td>
<td>10 s</td>
<td>&gt; 15 min</td>
<td>&gt; 1 day</td>
<td>&gt; 100 days</td>
<td>&gt; 30 years</td>
</tr>
<tr>
<td>bubble with 1 cc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bubble Test</td>
<td>any</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Sonic or ultrasonic sensor</td>
<td>any</td>
<td>+</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Ultrasonic bubble detection</td>
<td>any</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pressure rise</td>
<td>any</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Pressure decay</td>
<td>any</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Micro-Flow</td>
<td>various</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Mass Extraction</td>
<td>various</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Optical Emission Spectroscopy</td>
<td>various</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Magnetic sector field mass spectrometer, sniffing</td>
<td>Tracer gas $^4$He, $^3$He, H$_2$</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>2)</td>
</tr>
<tr>
<td>Magnetic sector field mass spectrometer, vacuum</td>
<td>Tracer gas $^4$He, $^3$He, H$_2$</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

1) Possible with bubble collection and volumetric analysis
2) Accumulation test method only, see chapter 6 Leak detection methods

### How to select the right test method?

- Define the leak tightness requirements and allowable pressure/vacuum ranges for your product
- Test time requirement for complete test processes
- Product operation conditions and desired test direction
- Location of leak needed or only global leak test
- Destructive / non-destructive
- Accuracy and process control
- Required sample rate - Lab. or QC offline sample testing to 100% production inspection of all parts
- Desired grade of automation
The Micro-Flow technology is an integrated micro sensor based on accelerated flow. As air leaks from the component or assembly under test, the air lost is replenished via the Micro Flow sensor to maintain a constant pressure. The loss causes an electrical signal proportional to volumetric or mass flow. The micro flow sensor thereby operates with a pressure reservoir which is used to pressurize the unit-under-test (UUT) and has a sensitivity of $5 \cdot 10^{-4}$ mbar l/s. Often only simple fixtures are required for this type of testing method.

A special form of using the Micro Flow Sensor, is the Mass Extraction technique. The basic principle is based on a rarefied gas flow approach. In order to achieve a higher sensitivity, the test is performed under a vacuum. This method incorporates sensor designs operate at continuum/slip flow condition (shallow vacuum) and transitional/molecular flow regimes (deeper vacuum). For example this technology can be used for closed containers, as packages or electronic enclosures. Thereby the unit-under-test is placed into a vacuum chamber with a vacuum as low as 1 mbar or less. After the chamber is evacuated, the remaining flow between the chamber and the vacuum reservoir can be used to determine the leak rate of the tested part. With this approach a sensitivity of up to $6.7 \cdot 10^{-7}$ mbar l/s can be realized. Other approach can be applying vacuum inside the part and measuring the barometric air leaking in, simplifying and reducing the tooling cost.

The Micro-Flow and Mass Extraction technologies bring several benefits especially in comparison to other air leak testing technologies. The main advantages thereby are the speed of test and the low susceptibility against environmental changes. Furthermore, it has higher sensitivity and accuracy. It is thereby non-destructive and gives a quantitative test result. Also a daily calibration is not required.
## Product examples

For a more extensive product overview, please visit our website.

|                      | Pressure or vacuum range | Pressure – Micro-Flow \n|----------------------|--------------------------|-----------------------------|
| E-PDQ               | Pressure ranges 0 to 4.5 bar and higher | up to 12 bar | less than 69 mbar |
| E2                  | 2 \cdot 10^{-3} mbar l/s and higher | 7 \cdot 10^{-7} mbar l/s (0.2 \mu m defect size) |

| Dimensions (l x w x h) mm | 102 x 159 x 254 | 305 x 305 x 305 | 172 x 283 x 565 |

| Description | Leak test for high speed automatic production lines for small sized parts. Designed for easy integration. | Offered for industrial, rugged applications as well as aseptic and cleanroom applications for medium sized parts with high throughput. | High speed production lines for medium sized parts. Multiple instruments for inline testing of up to 120 ppm. Suitable for sealed packages and devices. |

| Typical applications | Consumer electronics, Medical devices, Small packagings | Automotive, Refrigeration and air conditioning, Medical devices | Packagings, Consumer electronics, Medical Devices, Sealed Components |

### Micro-Flow

**Pressure reservoir**

**Air path:** Tank – Tube – Hole

**Leak**

(UUT (Unit under test))

**Measure with Micro-Flow sensor:**

Gas (AIR) make up flow

### Mass Extraction

**Vacuum reservoir**

**Air path:** Unit under test – Chamber – Vacuum reservoir

**Leak**

(UUT (Unit under test))

**Measure with Micro-Flow sensor:**

Gas (Mass) extracted

### Key advantages / Customer benefits

- Recognized test method in several standards like USP 1207 and SAE standard provides process security
- 25 to 40% faster test time than pressure decay test increases efficiency of test process
- Low susceptibility against environmental changes provides increased test reliability
- User-friendly through factory calibration, no daily calibration required
- Non-sensitive to product volume changes, one set up can support multiple parts with different volume
**Optical Emission Spectrometry**

Integrity testing for high demanding pharmaceutical packages and advanced sealed devices

**The method**

The Pfeiffer Vacuum AMI, with its optical emission spectroscopy is especially suited for pharmaceutical applications. Especially the stability of the primary packaging integrity to assure sterility and to protect the pharmaceuticals against microbiological, oxygen or moisture ingress is very critical.

The patented method does not require any specific tracer gas. Instead the gas mixture present in the container head space of the packaging is used to perform high sensitivity testing over a large detection range. The test method is thereby applicable for different kinds of packaging like blisters, pouches, vials and plastic bottles and can also be used to test sealed devices like battery cases.

**Core strengths**

Thanks to its large detection range, the AMI can replace helium leak testing and gross leak test with one system. It delivers a user-independent, deterministic go / no go result and also enables quantification of the leak test result. Therefore, the calibration validation is based on certified calibrated leaks and offers high reliability and accuracy according to USP 1207.1.

The software solutions used in the AMI are compliant with 21 CFR part 11. Optional software solutions are available for a manufacturing execution system. Trend analysis can be implemented in the software for early indication of drift production and packaging equipment.

With the extensive test results and the high accuracy and repeatability, the AMI is especially suitable for validation and stability tests as well as for the use at R&D laboratories.

**Application examples**

- Blister packs
- Glass vials
- Plastic bottles
Specific application example: Blister packs

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Down to $2 \cdot 10^{-5}$ mbar l/s (Equivalent to ~2 µm pin hole)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test duration</td>
<td>Down to 20 sec per test (Depending on the pack format)</td>
</tr>
</tbody>
</table>

Advantages at a glance
- Widest detection range available on the market
  - Higher sensitivity than conventional methods
  - Can replace Helium and blue dye test
- Can test packs that contain tablets / capsules in multiple material / design formats
- Can test multiple packs per test cycle
- Applicable to peeling blisters

Product introduction
The standard configuration of the AMI comes with a 204·132·9 mm test chamber, but the chamber can easily be customized for specific packaging. Pfeiffer Vacuum supports customers from the Pharmaceutical industry through the entire GxP implementation process if requested.

Key advantages / Customer benefits
- Large detection range with higher sensitivity than conventional tests can ingress efficiency by combining gross and fine leak test
- Peace of mind through user independent and deterministic test result and high repeatability
- Easy to use due to automatic calibration based on traceable calibration leaks and go / no go result
- High flexibility - Applicable for different kind of packages as blisters, pouches, vials, plastic bottles and other devices
- Cost-efficient with fast return on investment
Tracer gas leak detection and especially helium leak detection is still the most sensitive commercially used test method on the market. Apart from the sensitivity, tracer gas leak detection offers various advantages. It is non-destructive, highly repeatable, conform with various regulations and faster than other methods. Furthermore, tracer gas leak detection offers the capability to also locate the position of a leak.

Tracer gases

The most common tracer gas for leak detection is helium, which offers the highest sensitivity. Furthermore, it is a noble gas and has no reactivity which makes it environmentally friendly and is approved for food and pharmaceuticals. As an alternative tracer gas, hydrogen can be used. While hydrogen has a cost advantage, compared to helium, it also comes with limited sensitivity.

Key features

Pfeiffer Vacuum offers the largest portfolio of helium leak detectors in the market. The modern portfolio offers portable solutions, multipurpose tools, modular leak detection, and high performance products with easy operation, due to large operator interfaces with color-/touch displays and high connectivity.

Application examples

- Pace maker
- Fuel tank
- Accellerator
### Key advantages / Customer benefits
- Helium leak detection has the highest sensitivity of all commercial test methods
- Additional advantages in regards to test time and accuracy
- Over 50 years of experience with the most modern portfolio in tracer gas leak detection
- Modern and easy to use operator interfaces
- Largest tracer gas leak detector portfolio with solution for all kinds of challenges
VACUUM SOLUTIONS FROM A SINGLE SOURCE
Pfeiffer Vacuum stands for innovative and custom vacuum solutions worldwide, technological perfection, competent advice and reliable service.

COMPLETE RANGE OF PRODUCTS
From a single component to complex systems:
We are the only supplier of vacuum technology that provides a complete product portfolio.

COMPETENCE IN THEORY AND PRACTICE
Benefit from our know-how and our portfolio of training opportunities!
We support you with your plant layout and provide first-class on-site service worldwide.

Are you looking for a perfect vacuum solution?
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