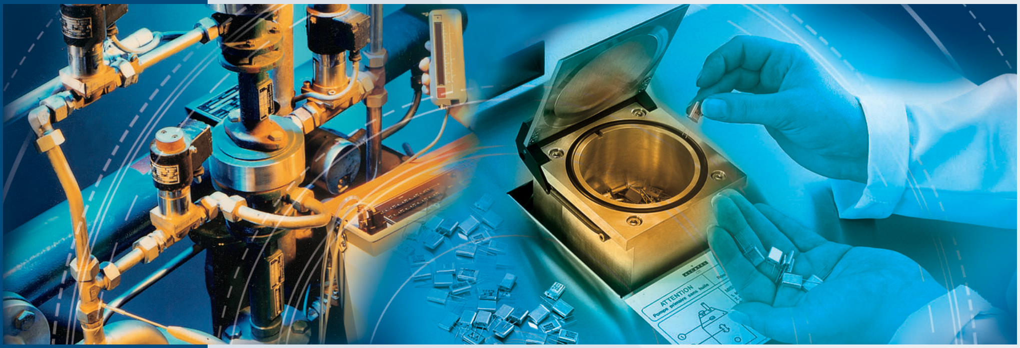
VACUUM TECHNOLOGY



Adixen by Alcatel Vacuum Technology

Helium Leak Detection Techniques

VACUUM TECHNOLOGY

A. Introduction

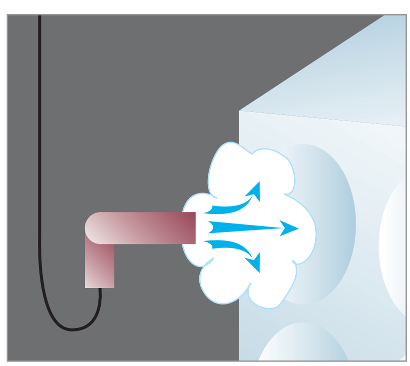
We have assembled in the following pages a number of useful elements that will help you:

- to get information about the various helium leak detection methods which are commonly used in the field
- to determine the best product for your application.

We have not presented an exhaustive examination in this chapter. Please contact the technical departments of Alcatel Vacuum Technology for advise and assistance on unusual leak detection applications.

LOCATION OF THE LEAK :
- maintenance applications
- quality control

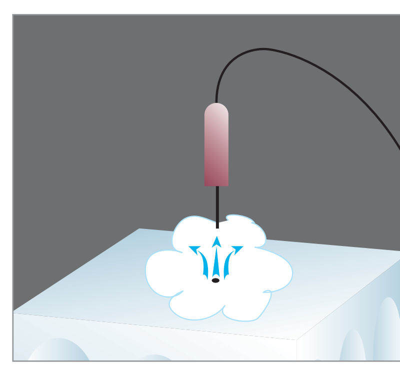
- the system or piece to be tested can be placed under vacuum
- you need to detect very small leaks



SPRAYING TEST
(vacuum methods)

see page 394

- the system or piece to be tested cannot be placed under vacuum
- the sensitivity is not a major issue



SNIFFING TEST
(sniffing methods)

see page 400

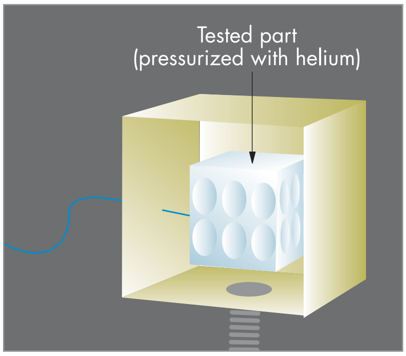
Leak detection is used to detect micro-openings, porosities, etc. in test parts. The detection of these cracks involves the use of a light tracer gas which is capable of infiltrating the smallest leak quickly: Helium.

The detector samples and measures the helium flow rate entering the test part via the leaks.

Several methods can be used to test the part. The right one will be selected according to the test part and the measurement accuracy required.

GLOBAL TEST :
- industrial applications
- quality control

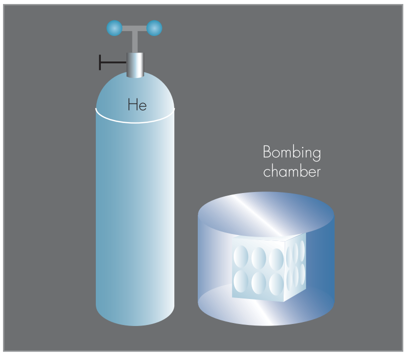
- you need to detect small leaks.
- the piece can be pressurized.



GLOBAL HARD VACUUM TEST (vacuum methods)

see page 397

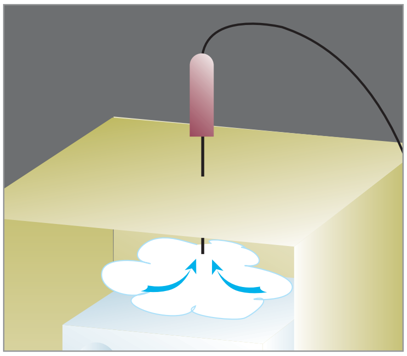
- you need to detect small leaks.
- the piece to be tested is a small sealed component.



BOMBING TEST (vacuum methods)

see page 399

- you only need to detect large leaks.
- the piece to be tested can be pressurized.



SNIFFING TEST WITH ACCUMULATION (sniffing methods)

see page 402

B. Vacuum methods

The vacuum method is the most sensitive leak detection technique.

It requires that one side of the part be placed under hard vacuum and the other side to be pressurized with helium.

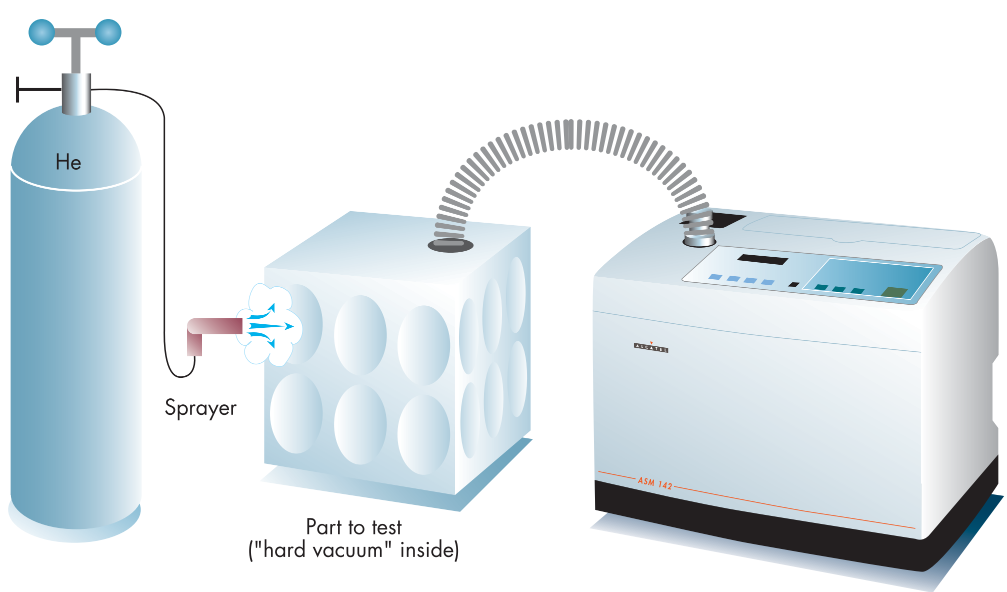
The side which is placed under vacuum is connected to the leak detector. If there is a leak, the helium that penetrates this side will be detected by the leak detector.

We will detail three variants of this method in the following pages :

- spraying test
- global hard vacuum test
- bombing test.

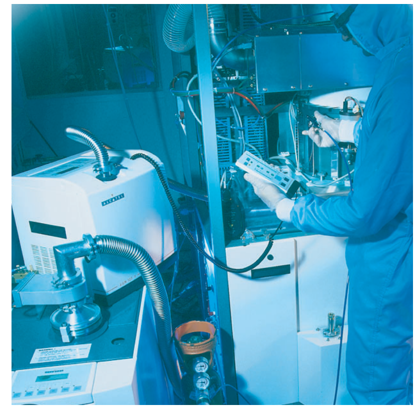
B.1. Spraying test

The spraying method (inboard testing) involves removing air from the test part, connecting it to the analyzer cell and then spraying helium over the outer surface.
Potential leaking areas are sprayed with helium.
The detector measures the flow of helium penetrating the part, and the leak can be located.



B.1. Spraying test (continued)

Applications



Leak test of vacuum systems (vacuum chambers, gas panel, …) and vacuum components (pumps, valves, gauges, mass-flow).

Quality control performed by the manufacturers (OEMs, vacuum manufacturers) and maintenance tests performed by the end-users.

Some applications:
- Semiconductor: thin-film systems, etching, sputtering
- Instrumentation: electronic microscopes, analytical systems
- R & D laboratories: particle accelerators, vacuum systems

Main advantages

- high sensitivity
- easy to perform
- local (or global) test
- relatively inexpensive

Notes

The system or piece to be tested must be placed under vacuum.
The connection between the piece to be tested and the detector must be perfectly tight (which means it is important to design adapted tools to connect the piece).
Check carefully that the material

Operating conditions

Helium rises in air, so the first rule for spraying helium is to start spraying at the top of the vacuum system and work the way down.
The second rule is to fully engulf the leak area with helium to properly size the leak (in other words, the placement of the helium spray is more important than the amount of helium sprayed).
One other reason for limiting the amount of helium is that excess helium can permeate the O-rings on your vacuum system and contribute a background level that may be high enough to mask the leaks you are seeking.

BEST PRODUCTS

¥ Basic needs : ASM 142

¥ Specific needs (large volume, very small leaks): ASM 182 T series

¥ Applications requiring dry HLD: ASM 122 D/ASM 182 TD+/ASM 192 T2D+

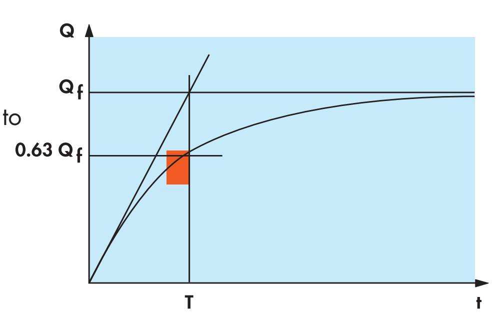
Response time

When spraying starts, the leak signal is not displayed instantaneously on the analyzer : the response time depends on the volume V being tested and the helium pumping speed S of the system at the opening of the part, according to the following relation:

$$Q = Q_f\,(1 - e^{\frac{t}{T}})$$

$$T = \frac{V}{S}$$

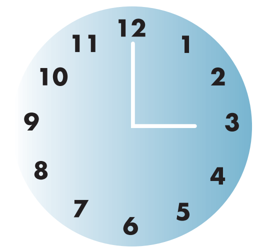
The response time T is defined as the time to obtain 63 % of Q_f.
Example:
Assume V = 50 l
S = 4 l/s
The time to obtain 63 % of the final leak rate will be 12.5 s



B.1. Spraying test (continued)

Disappearance time

Disappearance time is the time required for the leak detector to recover to its desired sensitivity after being exposed to a specific leak rate.



$$T_d = \frac{V}{S} \times 2.3 \times \log \frac{Q}{Q_m}$$

Where:

- T_d = disappearance time in s.
- V = volume in liters
- S = helium pumping speed in liters/second
- Q = leak rate in atm.cc/sec (measured)
- Q_m = smallest detectable leak (expected background)

Example:

Assume $V = 10$ l

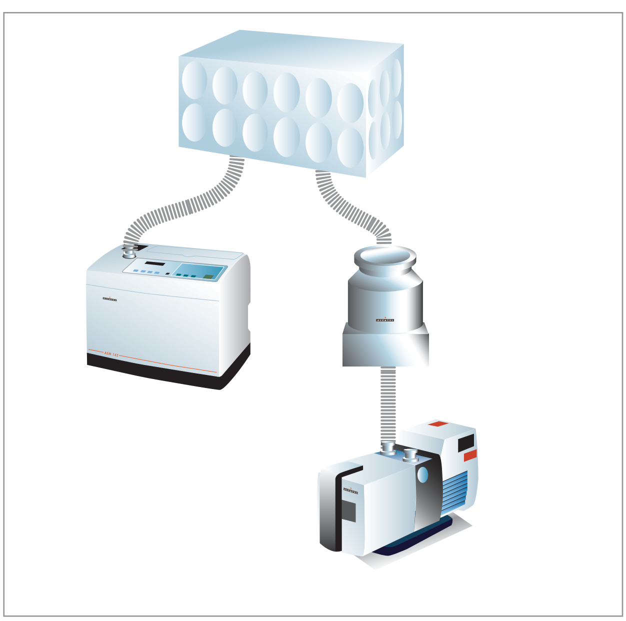
$S = 4.4$ l/s

$Q = 1.10^{-4}$ atm.cc/s

$Q_m = 1.10^{-8}$ atm.cc/s

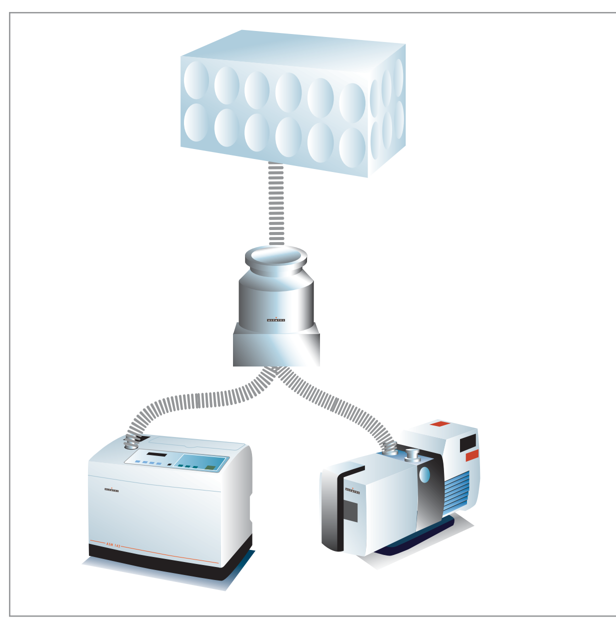
$T_d = (10/4.4) \times 2.3 \times \log (1.10^{-4} / 1.10^{-8}) = 21$ s

Advanced configurations



Helium Leak Detector in parallel operation (the detector is used in parallel with the pumping group to test the system).

Main advantage: the ability to increase the response time (because the helium pumping speed is higher).
Main issue: sensitivity affected by parallel operation, because of the split-flow.



Helium Leak Detector connected at the exhaust of the turbo pump.

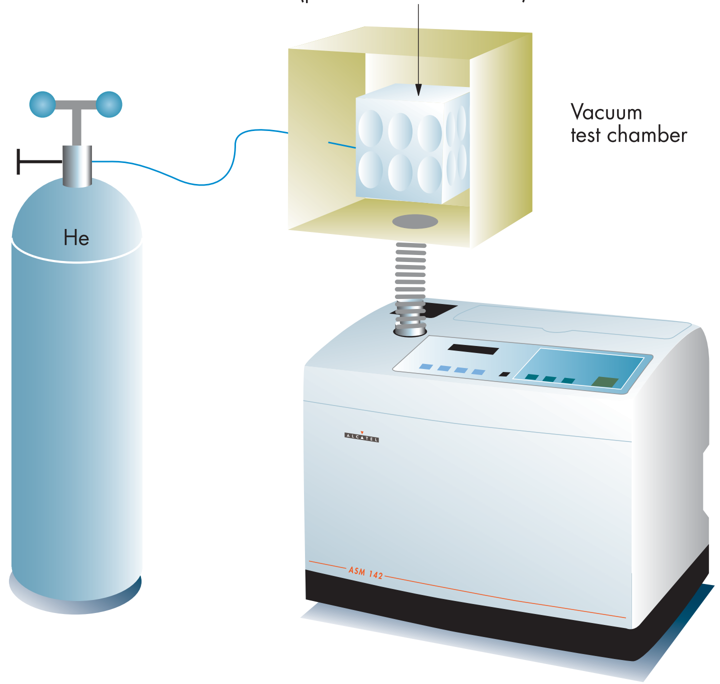
Main advantage: the ability to reduce the response time (because the helium pumping speed is higher) while keeping the highest sensitivity.
Main issue: difficulty for reaching the fine leak test mode, due to limitation of base pressure of the primary pump.

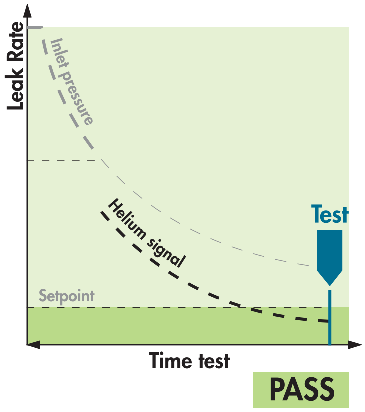
B.2. Global hard vacuum test

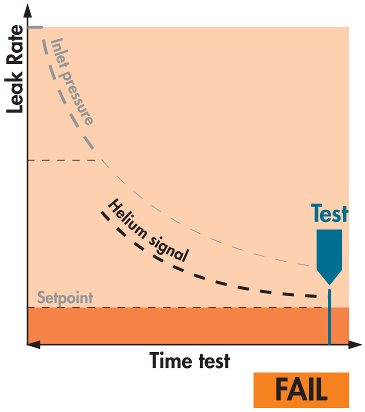
The hard vacuum test involves filling the test part with helium, placing it in a test chamber connected to the the analyzer cell and removing air from the chamber.

The detector measures the flow of helium escaping from the part through all the leaks at the end of the test cycle.

The leak cannot be located (global test).







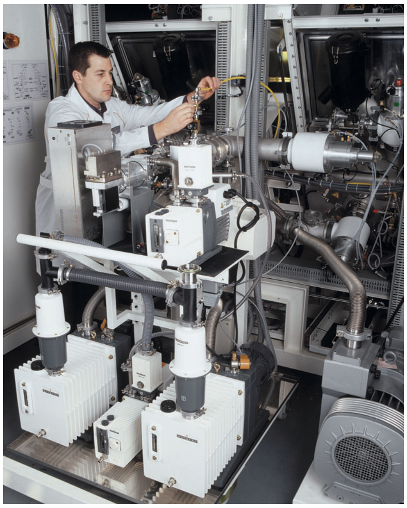
Applications

Mainly used to perform an industrial quality test in a production facility

The test is performed thanks to a dedicated leak test system integrated into the production line.

Some applications :

- Automotive: evaporators, condensors, airbags, radiators, fuel tanks, ...
- Refrigeration: compressors
- Mechanical: drums, fire extinguishers
- Electrical: SF6 circuit breakers, lightbulbs
- Pharmaceutical: blisters



Pumping unit integrated in an industrial Leak Detection Systems

B.2. Global hard vacuum test (continued)

Main advantages

- high sensitivity
- high throughput
- easy integration in a production line (loading/unloading + interface with PLC/PC)

Notes

The connection between the piece to be tested and the detector must be perfectly tight (which means it is important to design adapted tools to connect the piece).
Some leaks can be missed if the part to test is not pressurized under operating conditions.

BEST PRODUCTS

- ¥ **Basic needs: ASM 142 or ASM 182 T (depending on the volume of the test chamber)**
- ¥ **Integration in a turnkey system (very high throughput): ASI 20 MD**

Pump down calculation

$$T = \frac{2.3 \times V}{S} \times \log \frac{P_1}{P_2}$$

Note: The above formula is valid for clean, dry, and empty parts with a constant pumping speed.

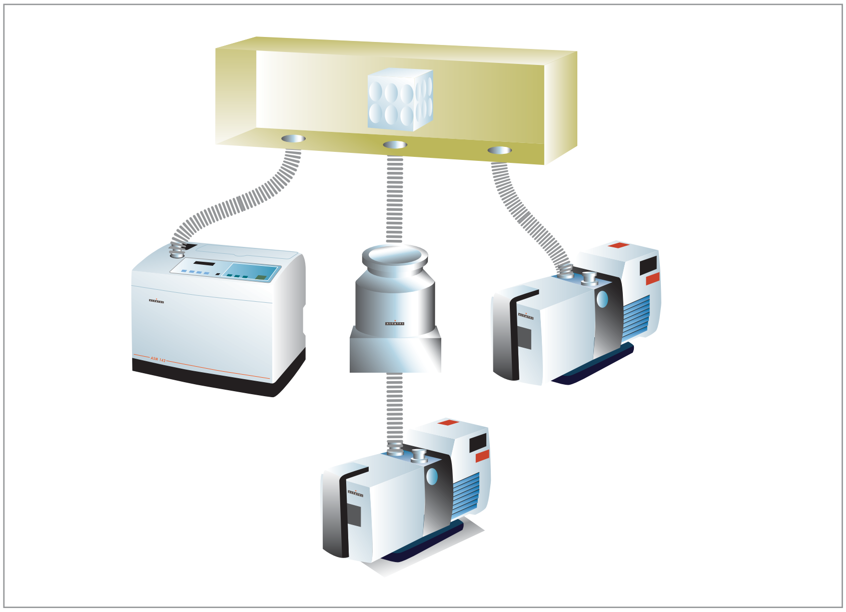
Where:

- T = time in s.
- V = volume in l.
- S = inlet pumping speed in l/s
- P_1 = start pressure in mbar
- P_2 = test pressure in mbar

Example:
Conditions V = 40 l
S = 3.5 l/s
P_1 = 1000 mbar
P_2 = 2 mbar
T = ((2.3) x 40/3.5) x log (1000/2) = 71 s

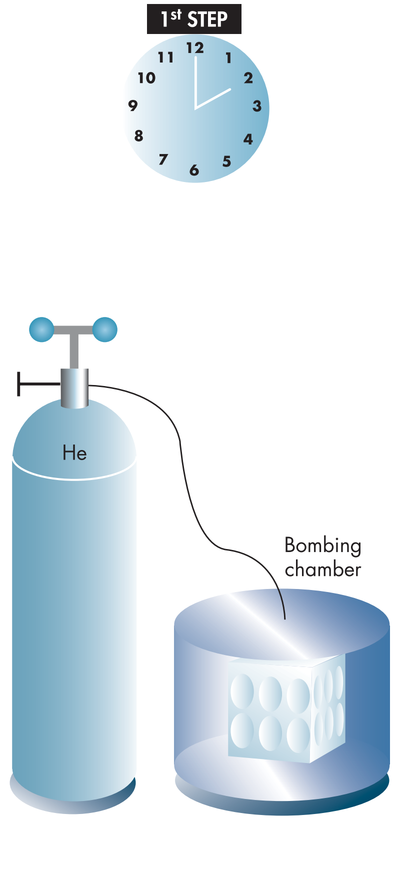
Some configurations

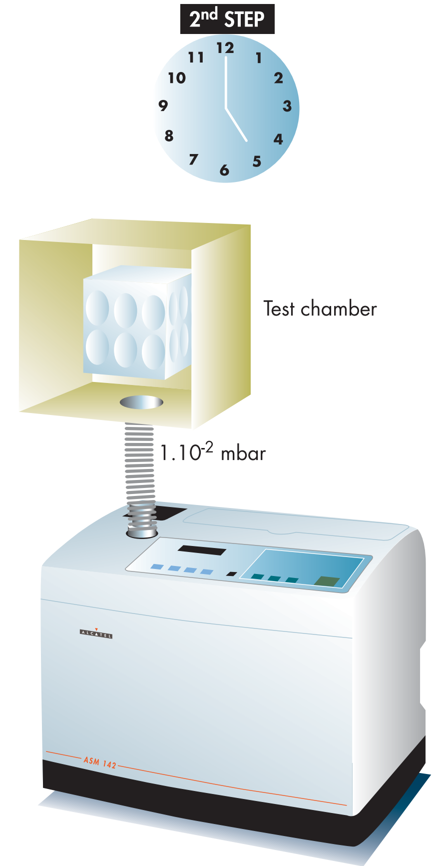
Piece to be tested with a standalone unit:
-> small pieces
-> small vacuum chamber
(ex: Airbags with ASM 182 T or ASI 20 MD)



Piece to be tested with a complete system (integrating a pumping package):
-> large pieces
-> high throughput
(ex: condensers/evaporators, airbags)

B.3. Bombing test





The bombing method is used for sealed objects that cannot be connected directly to the detector (semiconductors, waterproof watches, …).

The part is placed in a chamber containing pressurized helium (bombing chamber). The helium penetrates the part if it has a leak.

The part is then removed from the chamber and placed in a vacuum chamber which is connected to the detector. The helium escapes from the part through the leak and produces a signal (*Refer to "Global hard vacuum test" page 397, for more information*).

A measurement of the signal can be made, but it is necessary to take into account several parameters :

- the pressurization time
- the helium bombing pressure
- the internal volume
- the size of the leak.

Applications

Production quality test performed thanks to a dedicated leak test system (DGC type).

Some applications:

- Electronic (back-end): sealed semi conductor devices (quartz,
- Instrumentation: thermal sensors, infrared detectors
- Medical: pacemakers, auditive implants

Main advantages

- The only solution to test sealed components with high sensitivity
- High throughput

Notes

- Reserved for small components
- Possible to miss gross leaks
- Time consuming for step 1 (bombing time and ventilation time must be strictly respected)

BEST PRODUCTS

¥ Standard needs (high throughput): DGC 1001

¥ Other possibilities: ASM 142 or ASM 182 T

C. Sniffing methods

The sniffing method is the easiest way to detect a leak.

In this method, helium is introduced into the component (or could already be present as part of the product to be tested).

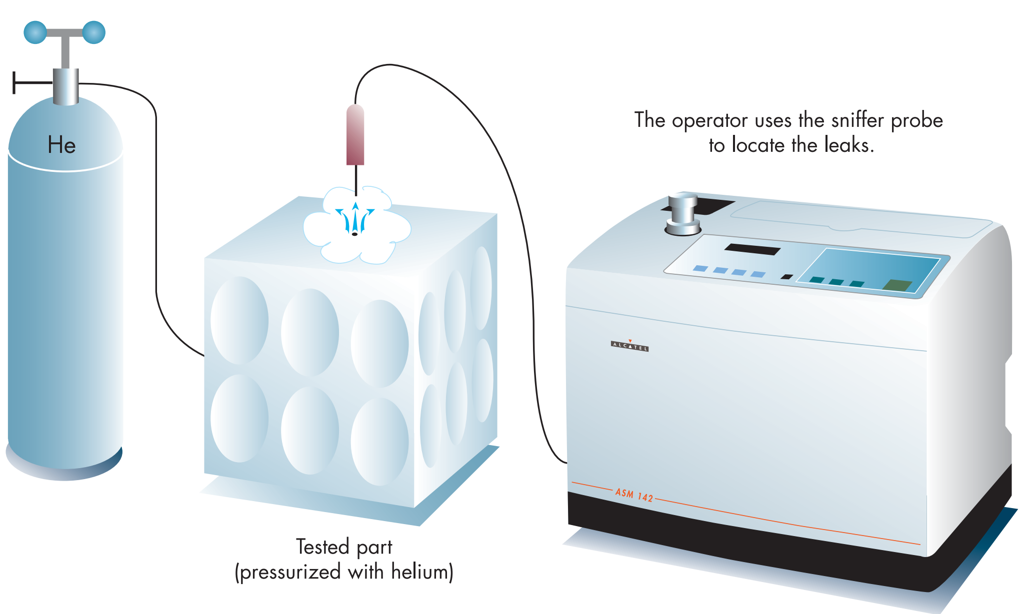
Helium leaking from the product to the atmosphere is detected by "sniffing" the outside of the article using a sniffer probe attached to a helium leak detector.

We will detail two variants of this method in the following pages:
- sniffing test
- sniffing test with accumulation

C.1. Sniffing test

The sniffing method involves pressurizing the tested part with helium. The detector samples the helium escaping from the part via a LDS (long distance sniffer) probe.

The sniffer probe is moved over potential leak areas and the leak can be located.



C.1. Sniffing test (continued)

Applications

Mainly used to leak test pressurized systems or systems usually filled with a liquid.

Quality control performed by the manufacturers and maintenance tests performed by the end-users.

Some applications:
- Refrigeration: air conditioning units
- Aeronautic: aircraft tanks
- Chemical industry: process lines, tubings
- Heavy industry: liquid natural gas carrier
- Other: telecommunication cables

Can be also used to measure the helium concentration:
- Fluid or smoke circulation analysis
- Geological or mining research

Main advantages

- Ability to locate the leak
- The system or piece to be tested does not need to be placed under vacuum.
- Very easy to perform
- Relatively inexpensive

Notes

- The sensitivity is limited by the helium background (due to the helium concentration = 5 ppm).
- The response time will depend on the length of the sniffer probe.

BEST PRODUCTS

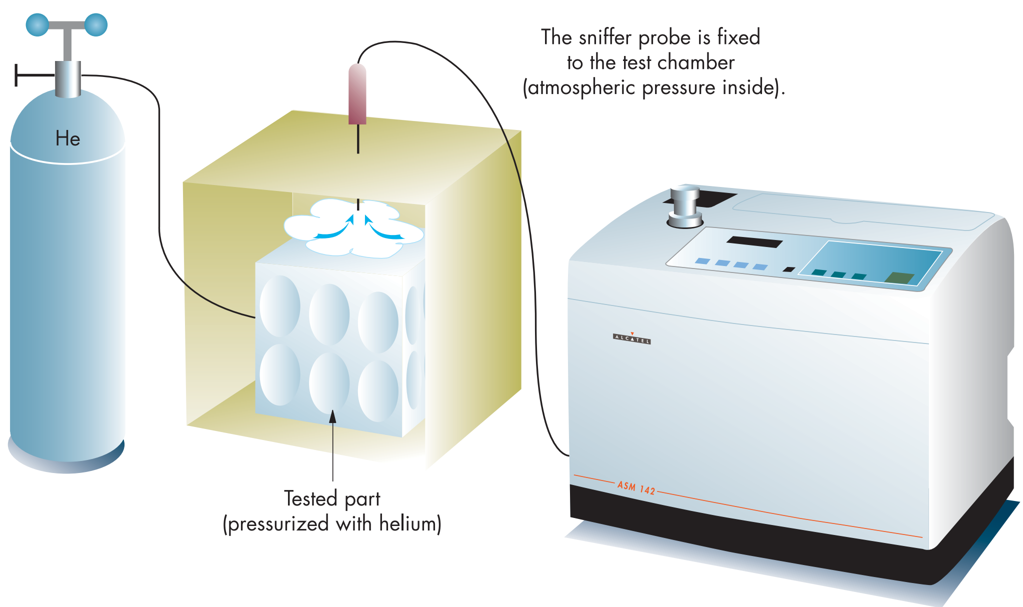
¥ **Basic needs:**
ASM 142 S (ASM 142)

¥ **Specific needs (transportation):**
ASM 102 S

C.2. Sniffing test with accumulation

The tested part is pressurized with helium and placed under a cover containing a sniffer probe.

The helium from the leak then accumulates over time inside the cover. The detector measures the concentration of helium, but the leak cannot be located.



Applications

Used to perform an industrial quality test in a production facility (when a hard vacuum test cannot be used):

Test performed thanks to a dedicated leak test system (can be integrated into the production line)

Some applications:

- Refrigeration: air conditioning units
- Mechanical industry: fire extinguishers
- Automotive: aluminium rims

C.2. Sniffing test with accumulation (continued)

Main advantages

- global test
- relatively inexpensive
- the system can be easily integrated in a production line (loading / unloading and interface with PLC/PC).

Note

- The volume between the tested part and the test chamber (free volume) must be as small as possible.
- The sensitivity is limited by the helium background (due to the helium concentration = 5 ppm).
- The cycle time will be longer in comparison with the hard vacuum method.

BEST PRODUCTS

¥ Basic needs:
ASM 142 S (ASM 142)

Calculation of the concentration

In case of leak, the helium concentration will increase:

$$˘P = Q \times t/V$$

Where:
ΔP = helium partial pressure increase in atm
Q = helium flow rate in atm.cc/s (leak rate)
t = duration of the test in s
V = accumulation volume in cc

We can measure the leak rate (Q) by measuring the helium concentration in the chamber.

Example:
Assume $V = 500$ cc
$\Delta P = 5.10^{-8}$ atm
$T = 25$ s

$Q = 1 \times 10^{-3}$ atm.cc/s

VACUUM TECHNOLOGY

Publication
Alcatel Vacuum Technology France

Photographs
Sémaphore

Aerial photograph
Marcel Chevret

Print & realization
ColorPress Communication

Conception & graphics
Amazone-SoHo -
ColorPress Communication