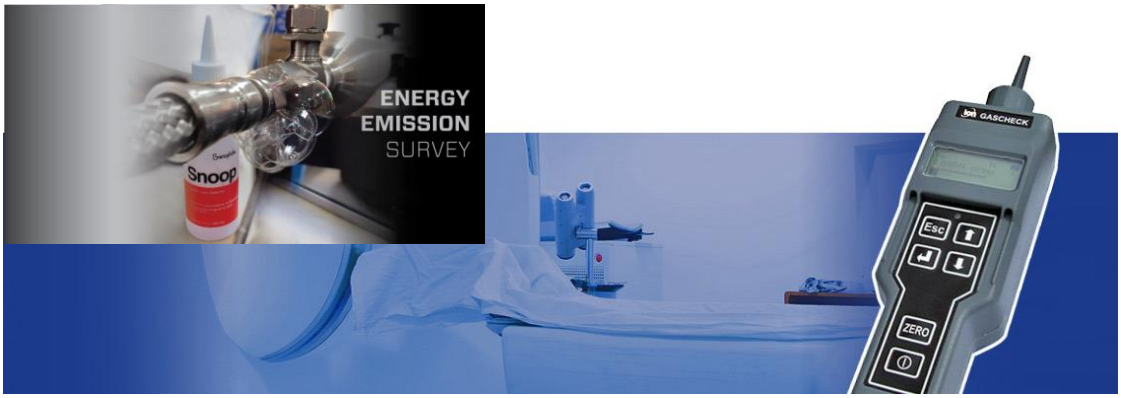
Find and Fix Leaks

The words "leak" and "leakage" appear in the field of vessels' hermetical closing and do not confront only with vacuum technologists but also engineers working with high pressures.

A leak means an unintended crack, hole or porosity in an enveloping wall or joint which must contain or exclude different fluids and gases allowing the escape of closed medium.

The basic functions of leak detection are the localization and size measurement of leaks in sealed products and systems.

For majority of examples, a leak test procedure is a quality control step to assure a device integrity, and is one-time nondestructive test.



Typical products in which the leak detection has to be used are: vacuum chambers, hermetically sealed electronic components, pressure vessels, aerosol containers, vacuum thermal isolation, pumps, refrigerating systems, chemical and nuclear plants, beverage cans, products containing metal bellows etc.

In spec of modern technologies it is practically impossible to manufacture a sealed enclosure or system that can be guaranteed to be leak-proof without first being tested. The main question is: what is the maximum acceptable leak rate consistent with reasonable performance life of the product.

Find and Fix Leaks

We can distinguish different types of leak sources:

Leaks caused by defects **in the containing envelope.**
For example a too thin wall of a plastic bottle becomes microscopic cracked at enough high pressure difference, or in canning industry if the score mark is too deep in ring pull-tab can top, or porous cast in machine housing metallurgy, etc.

Leaks in newly manufactured products **are most commonly imperfect joints or seals by which various parts are assembled to form the final article. There are known demountable and fixed joints. Between them the most often used are welds, brazed and soldered joints glass-to-metal and ceramic-to-metal seals, O-rings and other gaskets, etc.**

Pressure change method uses pressure gauges which are ordinary used to monitor the system performance.
Suspected leak sites can be squirted with a solvent (i.e. acetone or similar) while watching the gauge for a pressure rise that occurs when the solvent enters the leak.
This method has limited sensitivity (depending also on the type of pressure measurement cell) and some shortcomings (possibility of solvent freezing cause's temporary stuffing of leak, solvents may attack vacuum grease and elastomer gaskets).

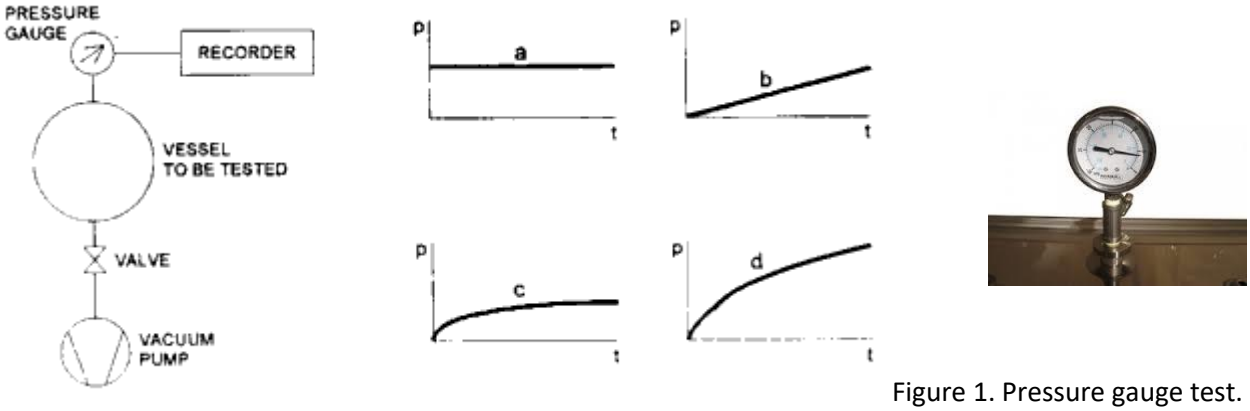


Figure 1. Pressure gauge test.

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Bubble test (soap painting)	-------	-------	-------	-------	-------	-------	------>								
Bubble test (air, water)	-------	-------	-------	-------	-->										
Bubble test (He, alcohol	-------	-------	-------	-------	-------	--->									
He sniffer	-------	-------	-------	-------	-------	-------	-------	-------	-------	--->					
Halogen sniffer	-------	-------	-------	-------	-------	-------	-------	-------	->						
Pressure decay	-------	-------	-------	-------	---->										
Acoustical	-------	-------	-------	-------	-------	->									
Vacuum decay	-------	-------	-------	-------	-------	---->									
Spark tester	-------	-------	-------	-------	------>										
Thermal conductivity	-------	-------	-------	-------	-------	-------	-------	------>							
Radioisotope	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------>		
Halogen detector	-------	-------	-------	-------	-------	-------	-------	-------	------>						
Mass spectrometer	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	------>	
Dye penetrant	-------	-------	-------	-------	-------	-------	-------	------>							
mbarl/s	100	10	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}

Figure 2. Sensitivity ranges of various leak detection methods

Overpressure methods

Can be performed by fluid or gas with which the tested element must be filled. As a fluid usually the water from house installation is used. Observing the outside surface the wetted areas show us great leaks and smaller ones up to approx. I mbar l/s. Testing with gas, the vessel is subjected to overpressure of some bars (depending on material and wall thickness) and immerged into the water. At leaks the gas bubbles begin to escape. In this manner the leaks up to 1. 10-3 mbar l/s can be detected. If the vessel is too great for immersion, the suspected points should be painted by soap solution and again we can see the bubbles escaping if there is a leak. This method enables detecting the leakage up to 10-5 mbar l/s and is usable also for very large systems.

Halogen leak detectors

Are used in the detector-probe mode (to 10-3 mbar l/s), requiring that the system be pressurized with a gas containing an organic halide, such as one of the Freons. The exterior of the system is then scanned with a sniffer probe sensitive to traces of the halogen -bearing gas (Fig. 3). The principle is based on the increased positive ions (K or Na) emission because of sudden halide composition presence. The ion current is the measure for a leak size. Halogen detectors can be used also in turned mode: evacuated vessel is connected to detecting instrument and is sprayed by Freon. In this manner its performance is up to 5.10-7 mbar l/s and is used in rough, medium and high vacuum.

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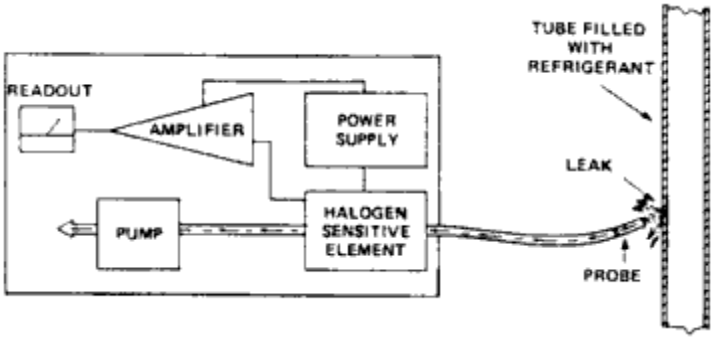

Figure 3. Sniffer probe test.

Mass spectrometers as leak detectors

Are used as most sensitive instruments for stating leak existence and presence in vacuum systems. They are adjusted on the atom respectively molecular weight of tracer gas. It is usually helium because of.
- its small mass and atom volume assures good supply of gas through a leak - relative great mass distance from neighbor mass enables greater sensitivity - its partial pressure in air is low, approx. 4.10-3 mbar

The first next suitable gas for leak detection purposes would be H2 but it is dangerous and residual atmosphere in vacuum systems always contains this gas. There are also spectrometers adjustable to other gases e.g. Argon.

HELIUM MASS SPECTROMETER (MS) LEAK DETECTION

Helium leak detection systems work as follows:
He is introduced to a test part that is connected to the leak detector.
The helium travels through leak into the leak detector, its partial pressure is sensed respectively measured and results are displayed on instrument as flow rate.

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The main part of the device is mass spectrometer, a sensor for different gas masses. In very low pressure (or vacuum) the molecules of rest gasses are transformed in ions by electron impact. Separating the ionized particles of different mass to charge ratios (q/m) it is possible to state the partial pressures of present gases - in our case also the presence of the sought gas helium. For helium MS- leak detectors, magnetic sector type mass spectrometers are preferably used as gas search sensors. The low pressure (less than 2x10-4 mbar) required for operation of the mass spectrometers is produced by an integrated high vacuum pump system. The auxiliary vacuum pump required for rough pumping the tested equipment is either incorporated or can be attached via suitable connection.

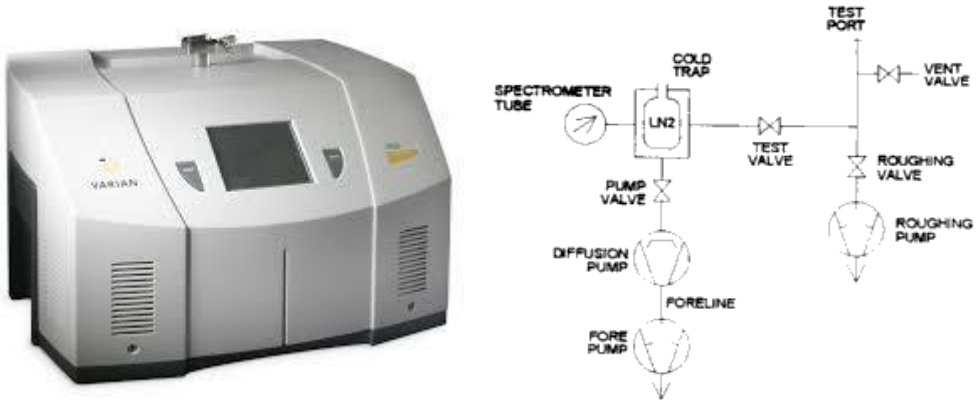

Figure 4.

<u>How to use a helium MS- leak detector?</u>

There are basically four different techniques for finding leaks: two "OUTSIDE-IN" and two "INSIDE-OUT" methods (Fig.5).

In the most commonly used "outside-in" technique, the sample to be tested is connected to leak detector and evacuated (Fig.5a). Than its surface is "probed" with a pointed jet of helium. Coming over a leak detector gives an acoustic or visible sign (exactly location) and the data about leak size.

The second technique (Fig.5b) consists of evacuating and hooding the sample with something like a plastic sheet and flooding the hood with helium. So it is possible quickly to establish whether or not a sample leaks and to establish the total leak rate. This technique is most useful on production lines where a test piece must be accepted or rejected.

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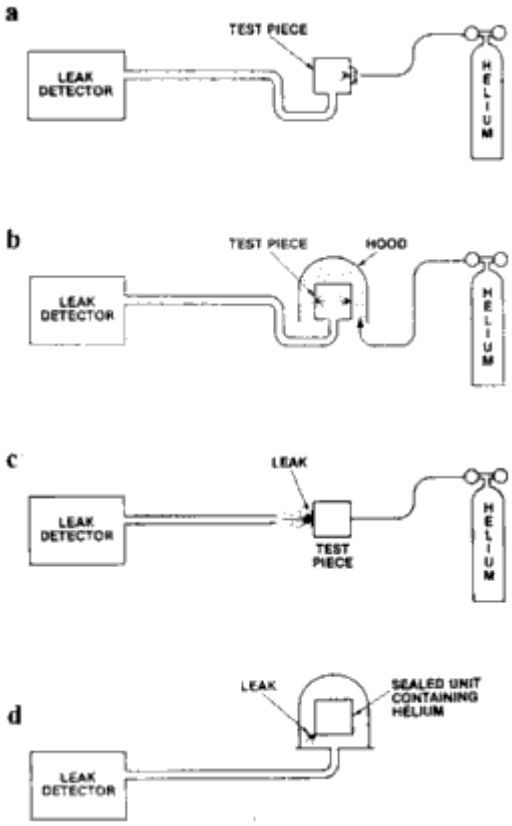

Figure 5.

In "inside-out" techniques the test configuration is reversed. Instead of being evacuated, the sample is pressurized with He. In this case the leak detector is equipped with so called detector probe and it can be used in two modes presented in figures 5c and 5d. In mode c) the test piece is probed with the detector probe around suspected leak sites. This method sensitivity (up to 1. 10-6 mbar l/s) is not as good as by others because the helium in the air is constantly being admitted into the detector.

Mode d) allows testing of a large number of samples simultaneously.
It is often called the bombing technique because the parts are previously placed in a pressurized He vessel where the helium leaks into the parts which leak.
All parts are than exposed to detector probe in closed container.
The mentioned leak test techniques are the main methods for establishing whether leaks exist and for locating where they are.
Each has its own advantages and shortcomings, each has also its own individual set of variations.