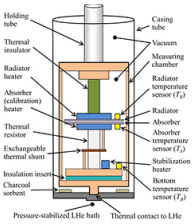
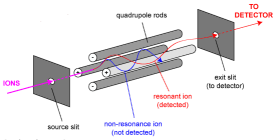


LEAK DETECTION:

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.



Quadrupole Mass Spectrometer.

Design of a leak detector with a mass spectrometer:

The operating principle of quadrupole mass spectrometers as shown above.

These units are used both purely as residual gas analyzers or process gas analyzers as well as for leak detection. Inlet systems for analyzing gas mixtures at higher pressures, including for leak detection. Gas analysis systems on the basis of quadrupole mass spectrometers can be used as multi-gas leak detectors.

The spectrometer cell of a leak detector as shown here also only works at pressures under 10^{-2} hPa. In leak detectors, this pressure is generated and maintained by the pumping system of the leak detector. This does not require any operator intervention.

Leakage Rate:

The rate flow of a gas that enters or exits a system through leakage rate. It is defined as the pressure rise over time in a given volume.

$Q_L = P.V/T$

Where,

Q_L = Leakage Rate

P= Pressure change during measurement period

V= Volume

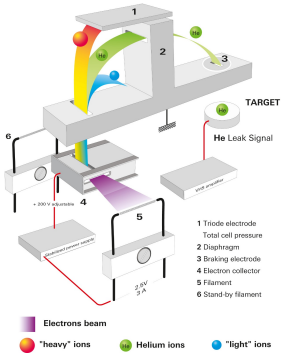
T= Measurement Period

Tracer Gases:

The test gases that are used for leak detection (also called tracer gases) should satisfy the following conditions:

They should

- Be non-toxic for humans, animals and the environment
- Not displace air, as hazardous situations, such as suffocation, could otherwise occur
- Be inert, i.e. slows to react, and should neither react chemically nor be flammable
- If possible not be present in air. Only with a gas that is present in the smallest possible concentration in the ambient air is it possible to detect even the smallest leaks



A mass spectrometer (spectrometer cell (8)) for masses 2, 3 and 4 (corresponding to test gases H_2, ^3He and ^4He) is attached to the inlet flange of a turbopump (high vacuum pump (7)). A backing pump evacuates the turbopump through the exhaust valve (6). A test specimen (in DIN EN 1330-8 also referred to as "test object") is evacuated through the inlet with the valve (3) open. Valves (6) and (3) are connected in such a manner that the required backing vacuum pressure of the turbopump always takes priority over evacuation of the test specimen. Once the test specimen has been evacuated, it can be connected to the backing vacuum or to the interstage pump of the turbopump via valve (4), depending on the pressure range concerned. Test gas is now sprayed onto the test specimen from the outside and together with the ambient air penetrates into the test specimen through leaks. The test gas present in the residual gas flows counter to the pumping direction through the turbopump via valves (3) and (6) to the spectrometer cell, where it is detected. The different compression ratios of the turbopump for air and the light test gas helium, which differ by multiple powers of ten, are utilized for this purpose.

While the high compression ratio of the turbopump keeps air away from the mass spectrometer, light gases arrive there at a relatively high partial pressure. The turbopump thus acts as a selective filter for helium and hydrogen. This is why a mass spectrometer enables helium and hydrogen to be detected in the test specimen even at pressures < 10 hPa (higher for some devices). Several powers of ten of the helium partial pressure, and thus a leakage rate range in the counter flow of between 1 and 10^{-3} Pa $m^3 \cdot s^{-1}$ can be covered by means of various interstage pumps in the high vacuum pump (4), as well as by operating it at different speeds that exponentially influence the compression ratio. A pressure in the range of several powers of 10^{-3} hPa must be attained in the test specimen and leak detector in the main flow for the highest sensitivity stage of the leak detector (intake via valve (4)).

- Not be mistakable for other gases
- Be quantifiable through test leaks.

The tracer gas helium satisfies all of these requirements. As a noble gas, it is not capable of chemically reacting. Only 5 ppm of it is present in atmospheric air, thus enabling even the smallest leakage to be detected. Since it is lighter than air, it does not pose a health hazard. Specific detection is possible using mass spectrometry, a highly sensitive and very selective analytical process (see chapters 6.1 and 7.2). There are many commercially available test leaks that are designed either as a diffusion leak or a flow leak.

LEAK DETECTION WITH TRACER GASES:

Helium Gas Detection

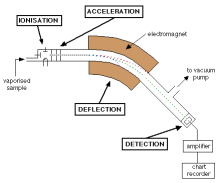
In this process high purity helium gas is released into the water system via specialized apparatus. The helium gas circulates around the water system and escapes through the leak point in the pipe wall. Helium separates from water and rises to the surface allowing identification of the exit point of water leak.

Hydrogen Gas Detection

In this method also the hydrogen gas in injected into the pipeline suspected of water leakage. Being the lightest atom, hydrogen escapes through the leak location and make its way to the ground where it is detected by gas sensitive device. Thus it helps detect the location of water leak. The precision of this apparatus facilitates the water leaks when other methods surrender.

Mass Spectrometer:

Mass spectrometry (MS) is an analytical technique that ionizes chemical species and sorts the ions based on their mass-to-charge ratio. In simpler terms, a mass spectrum measures the masses within a sample



The mass spectrometer and how it works.

Quadrupole mass spectrometers:

The filter system of a quadrupole mass spectrometer consists of four parallel rods arranged in the form of a square. Each pair of opposite rods designated (+) or (-), is connected to each other. Between the two pairs of rods, an electrical voltage consisting of a DC portion UU and an AC portion with amplitude V and frequency $f=\omega/2\pi f=\omega/2\pi$ applied.