TIPS AND TRICKS FROM THE EXPERTS

Reducing the measuring times of a leak detector

The tightness of machines and systems is a crucial condition for many production processes to ensure the quality of the manufactured products. Many technical end products such as the cooling circuit of refrigerators, air conditioning hoses in cars, gas tanks or rims do not properly work or do not work at all if they have a leak.

For detecting and localizing leaks under vacuum, helium leak detection has established itself as the optimal method. Compared to traditional methods such as bubble tests or pressure decay, helium leak detection delivers more precise and extensive data. Thereby, leaks can be localized reliably and moreover, production processes can be optimized. Helium leak detection is extremely precise, quantitative, and repeatable.

If the presence of any leak is suspected, a fast reaction is crucial for the system user: The leak shall be localized and fixed as soon as possible so that delays or downtimes in production are avoided.

Shortening the measurement period

For a given pumping capacity of the pumps in use, the response time of the leak detector will increase as the chamber volume increases. To shorten the measurement period and get faster results, there are different measures at hand:

By using a turbopump as a “booster”, the time constant of the vacuum system and therefore the response time during leak detection can be decreased. To do so, the turbopump is flanged directly to the chamber that needs to be tested. The

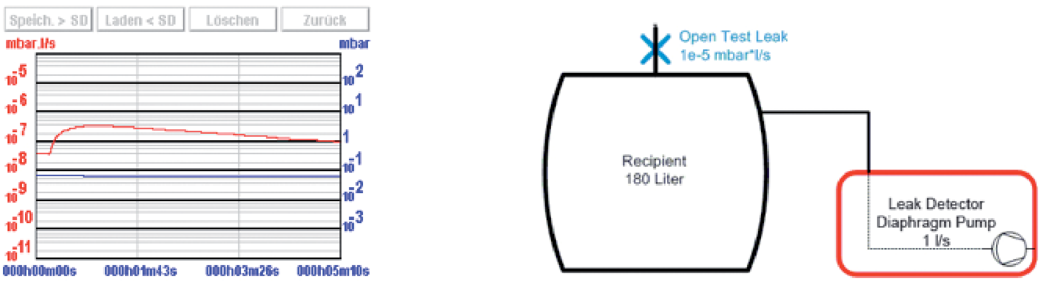


Figure 1: Slow signal rise with time delay due to low pumping speed

leak detector is used in series as a backing pump for the turbopump. This setup allows the response time to decrease, avoids any time delay of the signal and significantly increases the signal reduction speed after detecting a signal. For chamber sizes measuring several hundred liters, an auxiliary pump is useful - and is imperative for several cubic meters – in order to find leaks in an acceptable time frame.

If helium enters a vacuum system through a leak, the entering helium gas flow is transported through the chamber and expelled from the pumping system without losses. The gas flow rate can be directly measured by using a helium leak detector. The filling of the container up to a dynamic equilibrium value of the helium concentration occurs with the signal response time designated as the time constant of the vacuum system. For more details, see the info box or the Pfeiffer Vacuum leak detection compendium.

If a leak is not to be measured quantitatively but to be located, the suspicious sites only need to be briefly sprayed with small quantities of helium. The signal build-up follows the same laws described above. However, if the equilibration concentration of the test gas helium is not adjusted in the chamber, a signal decrease will once again be observed shortly after the rise.

Let's look at an example: A chamber should be tested with a leak detector and without additional auxiliary pumps. We have simulated a leak with a test leak and a leakage rate of $1 \cdot 10^{-6}$ Pa $\cdot$ m$^3 \cdot$ s^{-1} ($1 \cdot 10^{-5}$ mbar $\cdot$ l $\cdot$ s^{-1}). With a chamber volume of 180 liters and an effective leak detector throughput of 1 l/s, the time constant is 180 seconds. The tester would therefore have to wait 3 minutes until the signal has reached only 63 % of its actual intensity and would have to spray helium on the leak for that precise amount of time.
In practice, the tester would only spray for a significantly shorter period of time (1 s in our example), resulting in reduced signal intensity. In order to quickly return to a low background, the leak is rinsed with helium-free nitrogen after 20 s.

The low pumping speed leads to the slow signal rise shown in figure 1, with time delay of the signal. The displayed signal intensity is 50 times smaller than the value of the test leak. The slow decrease until the helium background signal has been reached is also unsuitable for practical use. After each spraying, the tester must wait 5 to 10 minutes to be able to carry out the next test.

Figure 2 shows the effects of a parallel pumping station with high pumping speed on the signal response time. The signal rise is significantly steeper, and the signal decay behavior in particular is accelerated to the background level. However, the signal intensity hardly changes. The pumping station acts as a competing pumping station suctioning most of the test gas, due to its parallel connection to the leak detector. Thus, this proportion of the helium can no longer be detected by the leak detector.

Figure 4 shows the signal response and decay behavior of a series connection of a high-vacuum pump and a leak detector. The high pumping speed of the turbopump leads to a signal rise to the nominal value of the test leak in the shortest possible time. The decay behavior is also significantly accelerated. However, in comparison to figure 1, not only the rise and decay behavior have been accelerated; the signal intensity is now correctly displayed and rises from the background by

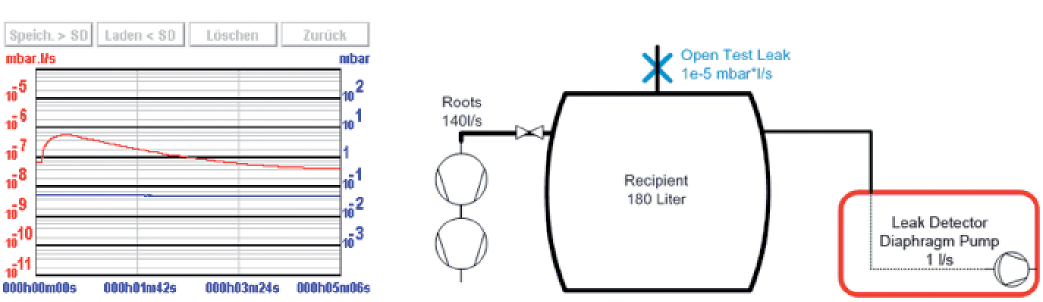


Figure 2: Steeper signal rise due to a parallel pumping station with high pumping speed

Info box

The time constant is determined by the volume of the vacuum system and the effective pumping speed of the pumping system.

$$\tau_{63\%} = \frac{V}{S_{eff}}$$

$\tau_{63\%}$ Time constant
S_{eff} Effective pumping speed
V Volume of the test object

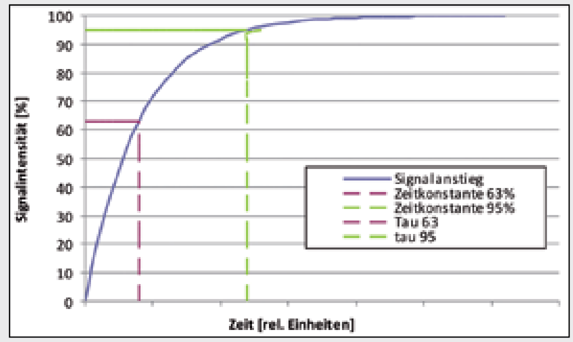
Formula 1

The temporal course of the increase displayed in Figure 3 can be modelled using Formula 2.

$$q_{He}(t) \quad = q_{He,end} \cdot [1 - e(-\frac{S_{eff} \cdot t_S}{V})]$$

$q_{He,final}$ Final value: He leakage rate
t_S Signal rise time [s]
S_{eff} Effective pumping speed [l/s]
V Volume of the test object [l]

Formula 2



Signalintensität = Signal intensity
Signalanstieg = Signal rise
Zeitkonstante = Time constant
Tau = tau (τ)
Zeit [rel. Einheiten] = Time [relevant units]

Figure 3

This process results in an exponential approximation to the nominal value of the test leak used. After three times the length of the time constant, 95% of the theoretical final value has already been achieved. This response time can be observed if helium is continuously fed in. Examples are test leaks with a reservoir or the integral test of a component under overpressure located in a vacuum chamber.

4 decades – when measuring with the leak detector alone, the signal only rose by a factor of 10.

Conclusion:

A turbopump as a booster has the following effects on leak detection:

- Fast signal rise time
- Fast signal decay time
- Avoids temporal smearing of the signal

In addition to the decrease in time required for the actual leak detection process, savings through, for example, avoiding system downtime and loss of production should also be mentioned. An external test leak to be connected to the chamber to be tested is highly recommended to measure the time required and the signal patterns.

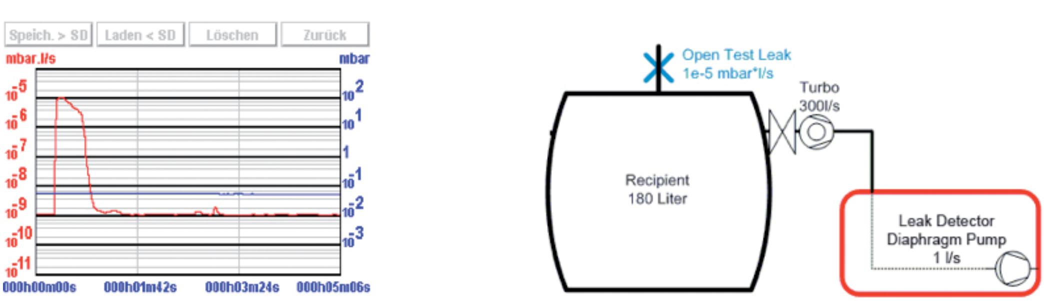


Figure 4: Signal response and decay behavior of a series connection of a high-vacuum pump and a leak detector.

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