PFEIFFER VACUUM

TIPS AND TRICKS FROM THE EXPERTS

Limitations of leak testing using the pressure change method

With regard to increasing environmental limitations, the tightness requirements for parts and components become more stringent. This is why many users apply testing methods based on the pressure change method for their processes. But these methods have limitations. To define and appropriately consider them within the production process, different factors are relevant: minimum detectable leakage rate, the volume and elasticity of the specimen, the resolution of the pressure gauge used, the permitted test time, and the temperature constancy during the measurement.

Effects of the individual physical values on the tightness

Colloquial expressions such as “technically tight“, “gas tight“, “virus tight“, “bacteria tight“, “water tight“ and “liquid-tight“ are not sufficient to describe a tightness requirement.

The limitations of the pressure change method can easily be illustrated with an example of the expression “liquid tight” with a leakage rate in the range of 10^{-6} mbar l/s. In a container with a volume of 5 liters, such a leakage causes a pressure loss of $2.0 \cdot 10^{-7}$ mbar per second. This would be $1.2 \cdot 10^{-5}$ mbar per minute, $7.2 \cdot 10^{-4}$ mbar per hour, $1.7 \cdot 10^{-2}$ mbar per a day, and 6.3 mbar per year.
The instruments in use must therefore be able to resolve these pressure changes.

$$Q_L = \frac{\Delta p \cdot V}{\Delta t}$$

$$\Delta p = \frac{\Delta t \cdot Q}{V}$$

Δ_p = change in pressure [Pa] or [mbar]
V = volume [m^3] or [l]
Δ_t = measuring time [s]
Q = leakage rate [Pa m^3/s] or [mbar l/s]

Resolution limitations of measuring instruments

The actual test with air as test medium is often carried out at absolute pressures ranging between 2 and 5 bar. If a testing time of one hour is permitted, this would mean that a change in pressure of $7.2 \cdot 10^{-4}$ mbar should be displayed on a scale of 5 bar. However, measuring instruments with such a high resolution are not available.

Impact of the volume on the pressure

The smaller the container is, the greater the change in pressure, and vice versa. With very small components, the use of commercially available measuring instruments for the abovementioned leakage rate limit may still be possible. However, the larger the container, the greater the chances that a leak test based on a pressure change method will fail.

Impact of the dimensional stability

The testing of elastic containers may also pose a problem. A volume change in a plastic container can compensate for pressure loss and make it impossible to carry out such tests.

Impact of the cycle time

It is very rare to have a cycle time of one hour during an in-process test. The demand for short cycle times with test objects from of a certain size upwards does not permit the use of the pressure change method.

Impact of the temperature

A quantity of gas enclosed in a container is subjected to the ideal gas law:

$$p \cdot V = \frac{m}{M} \cdot R \cdot T$$

p = pressure [Pa]
V = volume [m^3]
m = mass [kg]
M = molar mass [kg $kmol^{-1}$]
R = general gas constant [kJ $kmol^{-1}$ K^{-1}]
T = absolute temperature [K]

The pressure in the container is therefore dependent on the absolute temperature; its scale starts at -273.15 °C. The scale range corresponds to the Celsius scale. This means that a change in temperature of just 1 °C equals a pressure change of approximately 1/273. If the 5 bar container in the example above is heated up by only 0.1 °C, we create an increase in pressure of 1.8 mbar. This is more than a hundred times the pressure drop generated by the leak per day. This shows that by designing a pressure decay test system with borderline values, a test result can be influenced merely by touching the test specimen.

Thermally insulating materials on supporting devices and sealing tools, as well as mathematical temperature compensation can expand the limitations of pressure change methods, but they are not indefinitely effective. Measurements of components that come directly from heat treatment stations (such as welding, soldering, washing or drying) must be tested with the pressure change method only after undergoing cooling processes which include long waiting periods.

Leak detection and leak testing with test gases

Tracer gas methods, in which the gas flow of a test gas is passed through a leak with a selective detection device, offer a solution for the abovementioned limitations. Tracer gas methods are

- several orders of magnitude more sensitive than pressure change and bubble test methods
- largely resistant to temperature changes
- resistant to changes in volume in the case of elastic components
- not subject to restrictions where the specimen volume is concerned
- fast measurement methods, which allow short cycle times

Tracer gas methods also allow for a high degree of automation as well as an objective and operator independent test result according to standard-compliant test methods.

We would be happy to assist you in optimizing your vacuum solutions for specific applications – go ahead and ask us!

Are you looking for a perfect vacuum solution? Please contact us:

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