Technical Overview

Helium Leak Testing Pressurized Components Using the Accumulation Method

Abstract

Helium leak detectors operated in the sniffing mode have been routinely used to find leaks in helium pressurized objects. The sniffing probe is typically used by passing its inlet tip near the source of the potential leak. A leak rate signal is registered if the helium concentration at the tip of the probe increases from its background level. This method is capable of sensing leaks as small as 10^{-6} atm cc/sec while moving the sniffer probe at a maximum rate of one foot (25 cm) per second, if the probe tip is closer than approximately 1/8 inch (3 mm) from the leak source.

A variation of the sniffing method is to use a sniffer probe inlet that is fixed to an enclosure that surrounds the potential source of the leak. The enclosure needs to form an adequate seal to accumulate helium from the potential leak within the volume, which will result in an increased helium concentration. If the accumulation volume is relatively small, then leaks of 10^{-5} atm cc/sec and even smaller can be sensed through the sniffing probe after a short period of time. An example of the accumulation leak testing arrangement is shown in Figure 1. The primary advantage of using the accumulation method is that there is no variability of sniffer probe linear speed or distance from the part. Therefore, this method lends itself to being used for automated leak testing and does not require evacuation of the outside of the helium pressurized part. By using an Agilent leak detector in the sniff mode of operation, which can achieve a response time of <1 second, several items can rapidly be tested by sequentially opening and closing a shutoff valve at each accumulation device.

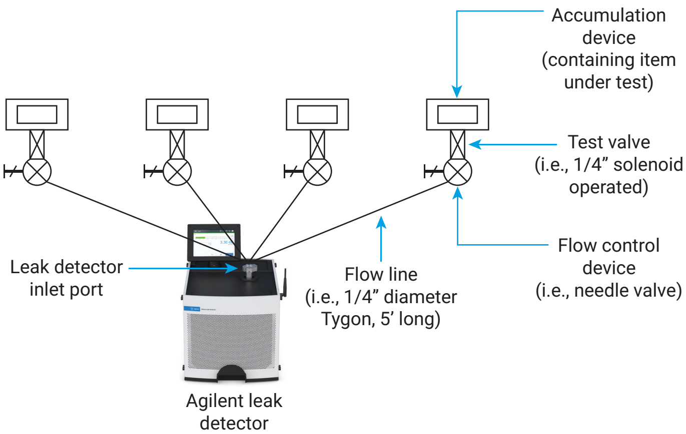

Figure 1. Multiple line accumulation leak testing example.

Helium accumulation in a confined volume

To detect a leak, the helium concentration in the tare volume (the space between the part and the accumulation enclosure) must rise above the ambient background level. The increase in helium concentration can be calculated by the following equation:

Equation 1.

$$C = \frac{(Q_{atm\ cc/sec})\ (T_{sec})(10^6)}{V_{cc}}$$

where:

- C is the increase in helium concentration in parts per million
- Q is the rate of helium flow from the leak in atm cc/sec
- T is the time it takes for the helium to accumulate in the tare volume in seconds
- V is the volume of the tare volume in cc

Note that Equation 1 assumes that the helium is uniformly distributed throughout the tare volume. If the helium is not distributed uniformly, the increase in concentration will be lower.

As an example, a part leaking pure helium at a rate of 1×10^{-5} atm cc/sec into an enclosed volume of 10 cc over 5 seconds would result in a helium concentration increase of 5 ppm. It is apparent from the above equation that increasing the concentration for higher sensitivity testing is achieved by minimizing the tare volume and/or allowing a longer accumulation time. The accumulation device should be kept as free as possible of openings or holes that have a venting effect, since their presence can lower the helium concentration buildup rate and maximum value. With smaller accumulators that are reasonably air-tight, the sniffer probe's air sampling flow can help increase the concentration buildup rate by a slight evacuation effect, since sampling flow rates often exceed 0.5 atm cc/sec.

With a suitably configured helium leak detector, a failed part indication should be based on a minimum recommended rise in the helium concentration of approximately 5 ppm. If a high helium background level in the testing area exists (over 500 ppm is not unusual), it would be necessary to look for larger helium concentration increases. Automatic or manual background compensation in the leak detector unit can help reduce the effects of high ambient helium levels while maintaining the desired testing sensitivity.

To correlate the leak detector's reading in atm cc/sec at a given time to the leak rate of the part, measurements should be taken from an appropriately configured accumulation device connected to a leak source of a known value. A calibrated helium leak or an actual part whose leak rate is independently confirmed can be used for this purpose. If required, a small diameter extension hose (i.e., <1/4 inch (0.5 cm)) can be attached to the calibrated leak to carry the helium into the accumulator. Several minutes of "soaking" time should be provided to make sure that the end of the extension hose from the calibrated leak source is delivering a steady flow of helium to the accumulator.

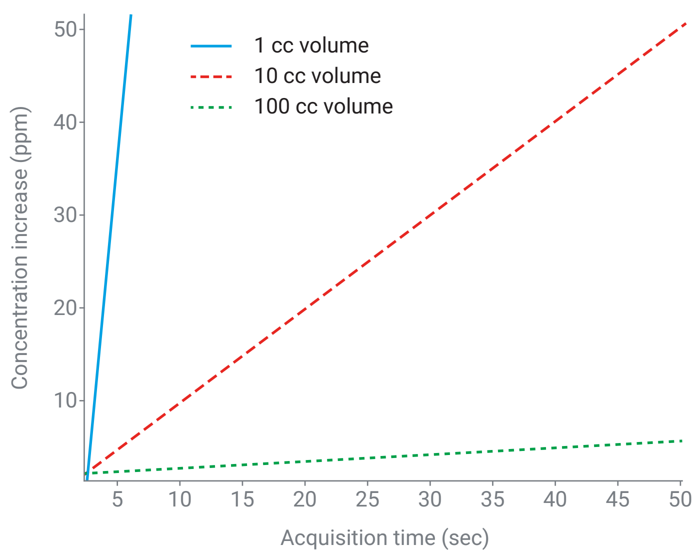

Figure 2. Helium accumulation rate versus volume for a 1×10^{-5} atm cc/sec helium leak.

Applications

Helium leak detection based on accumulation is widely used in various industrial applications where the detection of even small leaks is critical. The technique is reliable, versatile, and more sensitive than the traditional pressure/vacuum decay method. Here is a list of some common industrial applications:

- In HVAC and refrigeration systems production, accumulation is used to test the integrity of components, such as heat exchangers and pipes, to prevent environmental concerns or loss of cooling efficiency.
- In the aerospace industry, helium leak detection is crucial for verifying the integrity of aircraft fuel tanks, pressurized cabins, hydraulic systems, and other critical components. The accumulation methodology helps to prevent catastrophic failures and ensures the safety of passengers and crew.
- In pharmaceuticals and biotechnology, helium leak detection based on accumulation is used to verify the seal integrity of packaging materials such as vials, blister packs, and ampoules. It ensures the protection and shelf life of sensitive drugs and medical products.
- Accumulation helium leak detection is applied in the automotive industry to test fuel tanks, exhaust systems, and other critical components for leaks. Identifying and avoiding leaks improves vehicle performance and reduces emissions.

Summary

Although an accumulation device must be pre-installed on each part or site to be tested, and adequate time must be provided for accumulating the helium signal, this method has some key potential advantages. These include not having to evacuate the outside of the part (as in a vacuum-based testing arrangement) and not being operator-dependent on the exact location of the sniffer probe. With an appropriate setup, it also lends itself to automation and rapid testing of multiple parts or locations with one leak testing machine.

Product solutions

Agilent offers portable, benchtop, and mobile leak detectors that are designed for the accumulation sniffing mode.

Figure 3. Agilent portable, benchtop, and mobile leak detectors designed for the accumulation sniffing mode.

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