Running out of helium for your leak detection?
What about Hydrogen?

In this second part of the FAQ we answer our customers most frequently asked questions about the potential transfer from helium to hydrogen as a tracer gas.

Part 2: Practical tips

PFEIFFER VACUUM

The most important questions regarding the switch from helium to hydrogen as a tracer gas

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Back to basics?
Part 1 "Basics" is available for free at our Download Center

In the first part of this FAQ you will learn:

- the properties of hydrogen
- the limitations of hydrogen in leak testing
- the costs of hydrogen

What is this FAQ collection about?

Leak testing not only plays an important role in our daily safety and environmental protection, but also in the reliability of production processes and the quality of our everyday products. They represent an important step in the quality control of a product, for example in the automotive industry, in the pharmaceutical industry and in future technologies such as electromobility. The most commonly used specific tracer gas for leak detection is helium. In recent years, there have been regular reports that the global supply availability of helium is decreasing while demand is increasing. As a result, the price has risen rapidly, and distribution has been prioritized. The use of liquid helium in nuclear magnetic resonance scanners or in gaseous form as an additive to breathing gases enjoys higher priority than industrial use. Availability has become critical. In particular, small companies with limited helium requirements have difficulties in procuring helium. There is general concern about disruption to the helium supply chain and the resulting (costly) disruption to leak testing in production, even though this only consumes around 4–5% of the world's annual helium production.

As a result of this supply chain problem, alternative test gases are being identified. One of the most important alternative solutions is "forming gas 95/5" (95% nitrogen – N_2 / 5% hydrogen – H_2), which is becoming increasingly popular due to its lower price and high availability, as it is cheaper and easier to obtain. However, there is still little published information available on the results that can be achieved in leak testing with forming gas and the potential and limitations of using this tracer gas.

Part 1 and 2 of this FAQ collection therefore explain the possibilities and limitations of forming gas as a tracer gas for leak testing. It is therefore particularly important to understand the properties, advantages and aspects such as safety measures and calibration of the gas mixture in order to use it successfully. This FAQ collection concludes with a checklist. This checklist summarizes the FAQ collection and supports you in a potential switch from helium to forming gas as a tracer gas and contains all the relevant facts you need to know about the use of forming gas as a tracer gas in leak detection.

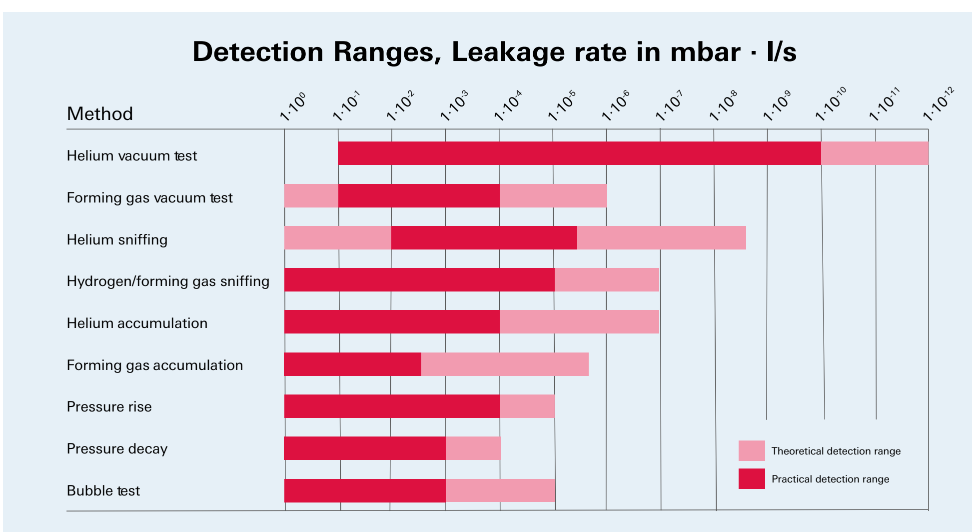
If you have more in-depth questions or need further advice, Pfeiffer Vacuum's application experts will be happy to help you find the right tracer gas for your leak testing needs. If you have any questions or would like to discuss the transition from helium to forming gas in leak detection, please contact our team of application experts **leak-testing-services@pfeiffer-vacuum.com**

What leak detection method can I use hydrogen for?

First of all, the application should be differentiated according to the use of hydrogen or forming gas. The undiluted gas is used on the one hand as a process gas, and on the other hand the use of pure hydrogen is required in regulations for the approval testing of media-carrying components in the hydrogen industry. In an industrial leak test, hydrogen is usually used as a 5% dilution in nitrogen, as forming gas 95/5.

Leak testing with hydrogen offers some advantages, but is not suitable for all applications. The following table shows the detection limits that can be achieved with different methods and the test gases helium and hydrogen. This should be considered depending on the leak rate and signal to noise ratio you wish to measure. Conservatively, the ratio of the useful signal (the leakage rate to be measured) to the noise (the signal background) should be at least 10:1. A design with smaller ratios is possible, but must still allow the useful signal to be clearly distinguished from the noise. This has an influence on the measuring equipment and process capability of a series test system.

The following figure shows the theoretical and practical detection limits of various leak detection methods with hydrogen/forming gas, air and helium.



What performance can I expect regarding background and speed of test?

When hydrogen is used, the background signal of the leak detector is higher than with helium. Typical values for mass spectrometric leak detectors are:

- After switching on: low 10^{-5} mbar · l/s
- After 2–3 hours: mid to low 10^{-6} mbar · l/s

These values apply to both a leak detector in sniffer mode and a leak detector in vacuum mode. In fact, unlike helium, the background is independent of the test method as it is dominated by the internal components of the leak detector. However, these values are only guidelines: the immediate environment of the leak detector and the condition of its components, e.g. the backing pump, have a major influence on the background that can be achieved.

With regard to the background signal, it is also important to operate the leak detector in an area where there are no other sources of hydrogen, for example:

- Welding processes under shielding gas (forming gas)
- Machining aluminum processing
- Battery charging stations
- Exhaust gases from combustion engines

These are some of the known sources of hydrogen. If these contaminate the immediate vicinity of the leak detector, they can lead to measurement errors. In tables, the hydrogen concentration in air is given as 0.5 ppm. However, this can easily reach values of over 100 ppm when the above-mentioned environmental influences are combined, which can lead to a higher background signal, especially for sniffer and accumulation measurements.

The test speed for sniffer applications is approximately the same when using hydrogen or forming gas and helium. DIN EN ISO specifies maximum values of 20 mm/s at a maximum distance of 1 mm. Industrial applications often place higher demands here, which require not only an analysis of the process gas but also consideration of the device technology. In particular, the pumping speed of the sniffer probe has a major influence on the possible travel speed.

Helium is the dominant tracer gas for vacuum methods. This is due not only to the lower signal background of helium, but also to the higher thermal velocity of light hydrogen, resulting in a longer signal rise and recovery time, especially at low test pressures. This often limits the use of forming gas to leakage rates above $1 \cdot 10^{-4}$ mbar · l/s for processes that are not too time critical.

How do I convert the helium leak rate to a hydrogen leak rate?

Forming gas is usually used in a sensitivity range in which laminar-viscous flow conditions prevail through a leak channel. This means that two factors must be taken into account when converting the helium leakage rate into a hydrogen leakage rate:

- The dynamic viscosity
- The tracer gas concentration of hydrogen

Influence of dynamic viscosity

When changing from one tracer gas to another, the flow behavior of the test medium changes due to the leak. Therefore, there will be an influence from the viscosity of the gas or its dynamic viscosity.

When converting from helium to hydrogen in the laminar-viscous flow range, you should multiply the leakage rate by:

- The reciprocal of the ratio of the dynamic viscosities of the two gases

$$\frac{\text{Leakage rate Helium}}{\text{Leakage rate Hydrogen}} = \frac{\text{Dynamic viscosity Hydrogen}}{\text{Dynamic viscosityHelium}}$$

Because of the dominant flow regime mentioned above, we neglect other flow regions, such as the molecular flow region.

This table shows the different values of the dynamic viscosities for pure hydrogen, forming gas and helium:

Name	**Gas**	**Sum or structural formula**	**Dynamic Viscosity [μ Pa·s]**
Hydrogen	H_2	H_2	8,9
Forming gas 95/5	95% N_2, 5% H_2	95% N_2, 5% H_2	17,5
Helium	He	He	19,1

Dynamic viscosity at 20°C

The dynamic viscosity of pure helium is 19.1 µPa·s and the dynamic viscosity of forming gas 95/5 is 17.5 µPa·s (according to DGZfP DP 01 at 20°C). Therefore, a factor of 1.1 must be applied to the helium leak rate when switching to forming gas.

This approach takes into account the flow of the respective medium through a given defect. Due to the different tracer gas concentrations of helium and forming gas 95/5 (see following paragraph) as well as pressure and temperature changes, additional corrections may be necessary.

→ Errors can easily occur during calculations: Do not hesitate to contact the Pfeiffer Vacuum team of experts, we will be happy to do the calculations for you!

Influence of the tracer gas concentration

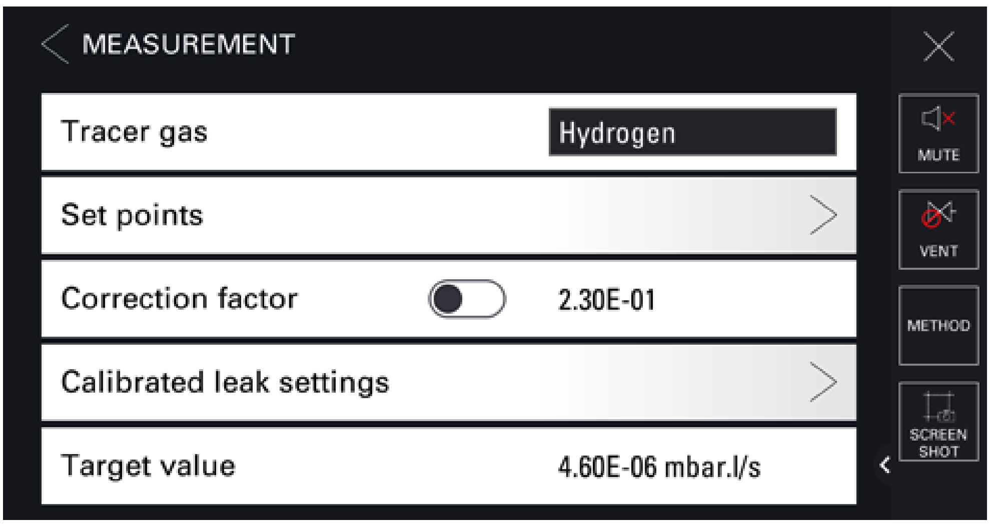
As hydrogen is often used in diluted form below the explosion limit, the influence of its dilution must be taken into account. For forming gas 95/5, a **factor of 20** must be applied to the signal to compensate for this.

→ The dynamic viscosity of hydrogen is significantly lower than that of forming gas. It is essential to note which medium you are referring to in your specification!

Leak detectors from Pfeiffer Vacuum are able to incorporate the correction factor directly into the measurement. By activating and setting the correction factor, the displayed signal takes into account the concentration of the test gas.

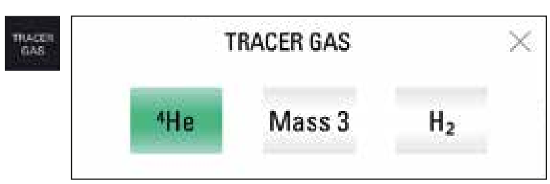
Can I use my current helium leak detector for hydrogen leak testing?

All current tracer gas leak detectors from Pfeiffer Vacuum are capable of measuring hydrogen. Switching from helium to hydrogen as the tracer gas is quick and easy with just a few simple settings. All you have to do is click on the "Measurement" menu and select the tracer gas you want to use in the "Tracer gas" section.



Tip: Use the “Tracer gas” function key for quick access from the main screen of your leak detector:

For quick access from the main screen, use the **[TRACER GAS]** function key.



Note: Display may vary depending on version, please refer to User Manual.

How can I calibrate my leak detector with hydrogen as tracer gas?

An external test leak is required for calibration with hydrogen. Calibration is possible in both vacuum and sniffer mode of the leak detector. Due to the natural background of leak detectors when set to hydrogen, the use of a leak with a value > $5 \cdot 10^{-5}$ mbar·l/s is recommended to achieve a good signal-to-noise ratio. For details on calibration, please refer to the operating instructions of the respective leak detector.

Every application has different requirements. Please contact the Pfeiffer Vacuum team of experts to determine the most suitable solution for your application.

The leak detector can be calibrated with an external test leak for hydrogen.

What if the limitations of hydrogen as a tracer gas prevent me from using it, but that I still want to reduce my tracer gas costs?

To reduce your helium consumption and therefore your tracer gas costs, you can consider several alternatives without changing the tracer gas you use. The first alternative is to invest in a helium recovery unit (HRU). Depending on the parameter settings and the helium tightness of the connected test systems, HRUs can recover up to 98% of the helium. Even though there are initial investment costs, the payback can be interesting in the long run, especially if your helium consumption is high.

Another alternative is the use of diluted helium: in fact, leak testing does not always require a high concentration of tracer gas and a diluted mixture can be used. Do not hesitate to contact your gas supplier to find out more about alternatives.

The use of diluted helium as a tracer gas in leak detection can reduce costs.

Checklist: These are key takeaways about hydrogen as a tracer gas in leak detection:

- [ ] **Stay safe!** Always use diluted hydrogen with a concentration < 5 %, ensure safe handling of pressure vessels and ventilate the test room.
- [ ] **Can you do it?** Before you develop your leak test method with hydrogen/forming gas, you should make sure that you can achieve the required sensitivity: Hydrogen has higher detection limits than helium!
- [ ] **Keep costs low and availability high!** Hydrogen is much cheaper and easier to obtain than helium.
- [ ] **Decide on the right method!** Different methods and different test gases offer different sensitivities, different achievable cycle times, etc. Make sure you choose the right method for your individual needs.
- [ ] **Watch your accuracy!** Pay attention to the correct conversion when changing your test recipe. Make sure that regular calibration is integrated into your process.
- [ ] **Stay in touch!** If in doubt, contact Pfeiffer Vacuum, our team of specialists will be happy to help you: **leak-testing-services@pfeiffer-vacuum.com**

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Are you looking for an optimal vacuum solution? Please contact us:

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