# **Leak testing of refrigerant circulation systems:** Important for people, nature and economy

Regulations governing the leak tightness of refrigerants are becoming increasingly strict. No wonder, since the immense potential of refrigerants to generate greenhouse gases is increasingly in the spotlight in the context of global warming.


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To meet regulations and reduce carbon emissions, there is a growing demand for improved, energy-efficient HVAC-R (heating, ventilation, air conditioning and refrigeration) systems and their quality and productivity standards. These demands are supported by modern leak detection systems that precisely ensure the leak tightness of cooling and refrigeration circuits.

## Basic operation of refrigeration and air conditioning

A cold beer from the fridge or a pleasant 20 degrees (70°F) in the office: people encounter refrigeration and air conditioning every day. While the refrigerator cools a small, insulated space, air conditioners keep our home, office space or a supermarket at a comfortable temperature. This is due to a physical principle that has been known for a long time: the alternation of gaseous and liquid states of aggregation.

Liquids that expand into a gaseous state extract heat from the surrounding material or surface. In an industrial setting, this process is facilitated by refrigerants. These evaporate or boil at much lower temperatures than water and enable heat to be extracted more quickly from their surroundings. In a nutshell, the refrigeration cycle essentially consists of a compressor, evaporator, condenser, expansion valve and various connection points. It also includes, for example, welds and bolted connections between the individual components. Each of these components must be leak tested to ensure that the complete system functions efficiently and sustainably throughout its life cycle. The significant global warming potential (GWP) of refrigerants is the basis for increasingly stringent regulations and standards in refrigeration and air conditioning.

## Rules and standards for refrigeration and air conditioning

The leak tightness of refrigeration and cooling systems is described by means of a loss in mass that occurs over a certain time. In refrigeration and air conditioning technology, the loss of refrigerant in a system is measured in grams per year (g/y). In homes and smaller restaurants and stores, refrigerant loss of 2 to 5 g/y is tolerated. If the refrigerant loss is converted to an equivalent leak rate with a tracer gas concentration of 100%, this corresponds to a leak rate of $1\text{-}5 \cdot 10^{-5}$ mbar·l/s. This defines a leak rate limit in the leak testing process in production. In commercial applications, such as hotels, office buildings and hospitals, the systems differ in size and complexity from residential applications. As a result, these systems have a higher susceptibility to leakage. In sum, a maximum refrigerant loss of 5 to 15 g/y is allowed here. In the industrial sector, the sum of potential leakage is a refrigerant loss of 15 to 30 g/y. This relates to chemical processes that use large-scale process cooling, such as in the production of food or pharmaceuticals.

To adhere to the requirements of regulations and standards, refrigeration circuits must be kept as leak tight as possible. Even the smallest leaks of 10 µm (by comparison:  a human hair has a cross-section of 40 µm) can cause immense damage. Consequences may include:

- Reduced system performance
- Increased energy demand
- Overheating
- Compressor damage and failure

This damage increases downtime as well as operating costs in relation to refrigerants, servicing and electricity – to name but a few. In addition, it can have negative effects on sales, the corporate image and above all: the acceleration of climate change.

At the same time, increasingly stringent regulations and standards present the industry with an ever greater challenge. The Kigali agreement is applicable at an international level. In Europe, the European F-Gas Regulation – EU No. 517/2014 applies. This is the origin of the various regulations and includes the restriction of various refrigerants that have a high GWP. By 2030, a number of refrigerants will be banned through a step-by-step reduction, which will entail a great effort on the part of suppliers and manufacturers: the entire system needs to be revised to ensure efficient and at the same time cost-effective operation of the overall system.

## Call for higher quality and productivity standards

Improved, more energy-efficient HVAC-R systems are required to meet the regulations. In addition, the demand for more stringent quality and productivity standards is growing, so leakage control already plays an important role in the production process. Therefore, two essential manufacturing steps are required before actual leak detection testing: drying and leak testing of the systems. These have a direct impact on the service life and performance of the equipment.

To ensure that leaks can be detected and repaired at an early stage, all components that come into contact with the refrigerant are tested individually. The requirements for the leak-detection testing process depend not only on the leak rate limit, but also on the tracer gas used and its concentration, the test duration, the degree of automation, and whether the test method is localizing or integral. In order to comply with the required leak rate limit, a leak test is carried out in a vacuum or an accumulation chamber after a gross leak test, using air-based test methods for example. In addition, a sniffing test can be used to localize the leak.

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Once the testing of the individual components has been successfully completed, the next production step is to assemble the individual components into a system and weld them together.  After an optional gross leak test with air, the refrigeration circuit is simultaneously evacuated and vacuum-dried.

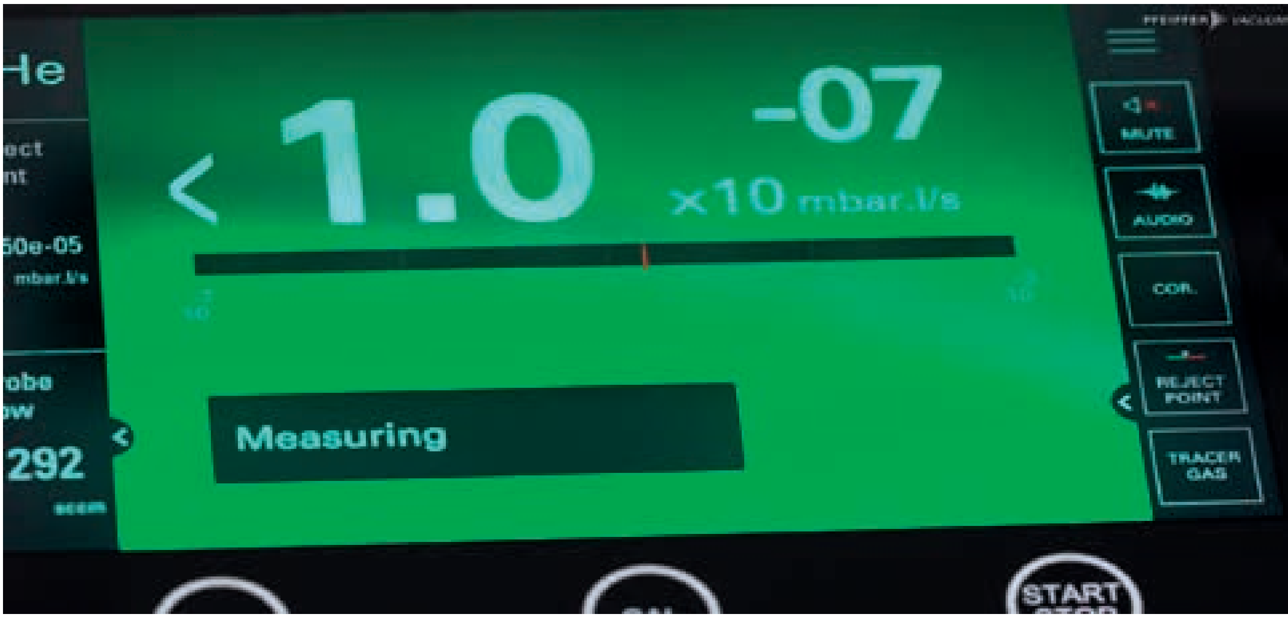
Leak detector ASM 306 S with sniffer probe

## Evacuation and vacuum drying for greater longevity

Evacuation and simultaneous drying of the system have an essential influence on the subsequent efficiency and reliability of the system. Particular attention is paid to drying the residual moisture: the challenge is to remove the thin layer of moisture adhering to the internal surfaces of the compressor, condenser, evaporator, valves and tubing. If the system is not actively dried, residual moisture remains, which can freeze during operation and cause failures in the expansion valve or closing pipe. In addition, water reacts with the refrigerant to form acids that can corrode or may also form deposits, threatening overall system failure.

Vacuum drying is therefore crucial for successful long-term operation of the system. It reduces residual moisture on the internal surfaces of the components and improves both the subsequent leak testing process and the filling operation with refrigerant. Typically, oil-sealed rotary vane pumps with a pumping speed of 10 to 30 $m^3/h$ are used for this purpose. The low pumping speed prevents residual moisture from freezing in the system, and oil-sealed rotary vane pumps achieve a stable ultimate vacuum.

Once the refrigeration circuit has been evacuated and vacuum dried, a tracer gas, such as helium or hydrogen is introduced. The test pressure should correspond to the subsequent working pressure of the system in order to reproduce a leak test under real conditions. To save costs in relation to the tracer gas, tracer gas concentrations of 100% are often not used. For the tracer gas to be distributed effectively in the system, the system must offer optimum conditions. This means: an airless space, without any humidity or other gases. Tracer gas recovery systems are ideal for systems with a large refrigeration circuit volume.




Intuitive menue for easy operation

## Reliable leak testing with the ASM 306 S leak detector

A sniffer leak detector is then used to test the individual welded and soldered joints, and the valves and connections. Leak tests with helium or hydrogen sniffers are far superior in terms of response time, accuracy and sensitivity to conventional leak detection methods, such as the water bath method or the pressure rise test. With the ASM 306 S leak detector, Pfeiffer Vacuum offers a state-of-the-art product that supports this application. This is because the helium and hydrogen sniffer leak detector is designed for 24-hour use, even in harsh environments. With its high sensitivity of 0.2 g/y it enables precise and error-free measurements that meet the stringent requirements of air conditioning and refrigeration applications. Designed to perform fast and repeatable measurements, this instrument offers short recovery times, even in the event of large leaks, ensuring maximum operational availability coupled with low maintenance and reduced service costs. Users therefore benefit from longer maintenance intervals and easier replacement of wear and tear parts.

> **With the ASM 306 S leak detector, Pfeiffer Vacuum offers a state-of-the-art product that supports this application.**

The ASM 306 S has a built-in calibration device for the sniffer probe

Sniffer probe of ASM 306 S with 5 m cable

The sniffer leak detector is not only convincing in terms of its accuracy and economy, its user-friendliness and intuitive operation also support efficiency due to the lightweight and ergonomic sniffer probe. The ASM 306 S achieves easy and precise results even from a large working distance and guarantees fatigue-free work on every working shift. In addition, the intuitive operation of the high-resolution 7-inch touch screen ensures easy operation, which is supported by color LEDs. Depending on the signal strength, these light up on the sniffer probe and ensure error-free readability in real time.

# Tip:

**Sniffer probe**

In order to have a greater range in your working area for leak detection, the sniffer probe of the ASM 306 S is available with a cable of 3, 5 or 10 m length available.

The ASM 306 S is available with different hose lengths for various applications. The compact design and low space requirements also make it easy to integrate in the production line.

The tracer gas leak detector covers all industrial sniffing applications and has proven itself particularly in leak testing of refrigeration and air conditioning units. The robust design of the ASM 306 S ensures low maintenance and operating costs with reliable use around the clock.

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