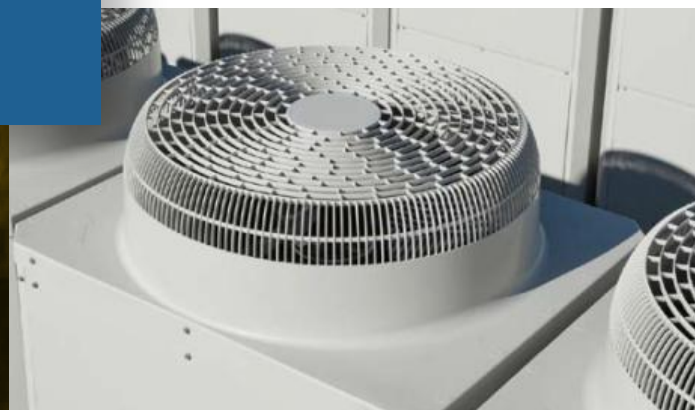
CINCINNATI TEST SYSTEMS

Your Global Leak and Function Test Solution Experts

Tracer Gas Leak Testing in the Manufacturing of HVAC/R Assemblies

AN OVERVIEW OF DIFFERENT TRACER GAS METHODS, THEIR PROS AND CONS, AND WHERE THEY WORK BEST



Click to start

Introduction

Small, nearly imperceptible leaks can affect the performance of air conditioners, refrigerators, heating systems, or any equipment that relies on a closed system.

Leak testing of pipe joints, tubes and fittings in refrigeration and air conditioning components such as coils and compressors during assembly manufacturing is critical. Tests must be accurate and reliable, or products could have serious problems for consumers in the field.

With heating, ventilation, and air conditioning (HVAC) systems, even a pinhole leak can dramatically impact performance as the unit loses coolant over time. These types of leaks need to be detected during assembly to weed out faulty parts and construction.

Leaks can be the result of faulty seals, fittings, hoses, and overall faulty parts. These types of leaks can also result from vibration, continuous pressure, or general wear. This is why you need a robust production testing method that is reliable and adaptable to detect various types of leaks.

There are various methods you can use for leak detection, including dunk testing, pressure decay testing, vacuum leak testing, and mass flow testing. For smaller leaks, tracer gas leak testing is the most precise. Freon leaks as small as 0.5 grams per year can impact HVAC performance and are difficult to detect using other leak test methods.

In this ebook we will review the basics of testing for leaks with trace gas and the capabilities, pros and cons of the different methods available.

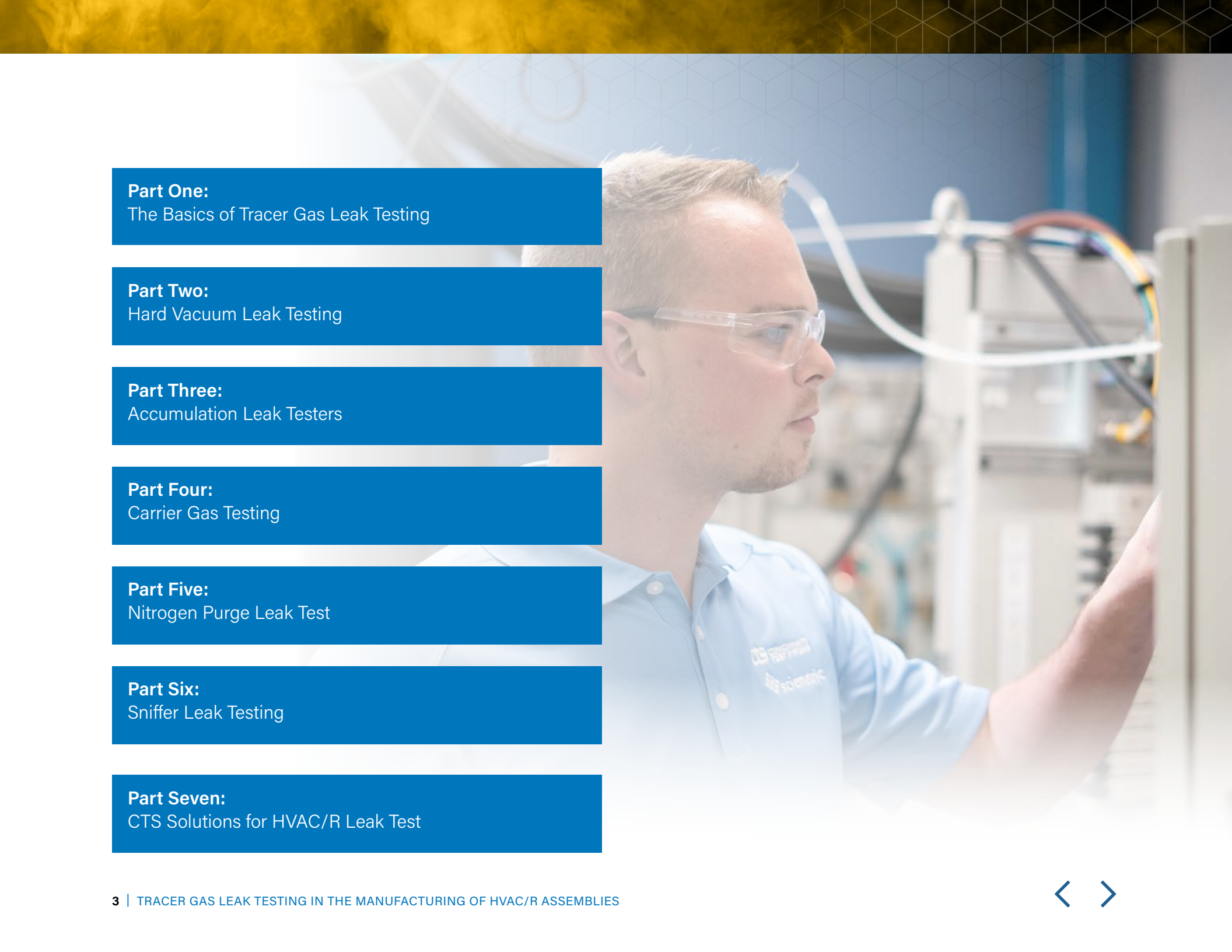
IMPACT OF REFRIGERATION SYSTEM CHANGES

Recent changes to testing requirements in the refrigeration and air conditioning industries have established that refrigerants like **R134A**, **R410A**, and **R404A** are considered greenhouse gases and not environmentally safe.

The replacement refrigerants are more energy-efficient and environmentally safe. Two popular ones are: **R1234yf** and **R600**. Manufacturers now must design products that operate utilizing these new more environmentally friendly refrigerants.

Unfortunately for manufacturers, these refrigerants have a flammable variant and are more expensive. Thus, the systems are being designed to use less gas, and the allowable and designated leak of refrigerant from a product has become less.

This means that leak testing must be very effective. The permissible leak rate is now 0.5 grams of refrigerant loss per year. This is comparable to one 3mm bubble being released underwater, every 1.2 hours (equates to mid 10-6 scc/sec range).



Part One: The Basics of Tracer Gas Leak Testing

Tracer gas leak testing is a simple and efficient method of leak detection. It is more accurate at finding smaller leaks than bubble testing and more sensitive than conventional pressure decay and mass flow testing.

Tracer gas detects escaping gas to identify micro-leaks. The basic principle is to surround the suspected leaking part or joint with a controlled background to create a stable test environment, then introduce a tracer gas. You can determine the leak rate using a mass spectrometer to measure the amount of tracer gas present.

Using tracer gases as a leak testing method provides greater sensitivity than other methods and can detect leaks in the range of 1x10-4 to 10-9 scc/s. It is also much faster than airflow or mass flow leak testing, and unlike other types of tests, tracer gas leak testing is not affected by ambient temperature. It also is highly reliable and virtually eliminates false leak failures.

You can use different tracer gases, but helium is used most often because it is non-flammable, non-destructive, non-toxic, and inert. There are also only small traces of helium in the atmosphere, reducing the potential of background noise. Pure helium can be used at 100 percent concentration, or it can be mixed with dry air or other gases such as nitrogen. To save on test costs and because of helium supply issues, some prefer to test with a forming gas, which is non-flammable and a safe mix of 5 percent hydrogen and 95 percent nitrogen.

The next sections review the different tracer gas leak test methods:

- Hard vacuum leak testing
- Accumulation testing
- Carrier gas testing
- Nitrogen purge testing
- Sniffer testing

BENEFITS OF TRACER GAS TESTING

- Enhanced sensitivity and resolution
- Increased detection of microleaks as small as 1x10-4 to 10-9 scc/s
- Boosted speed compared to air-flow leak testing
- Unaffected by temperature variations
- Reduced false-leak failures

Part Two: Hard Vacuum Leak Testing

This is the most common and accurate type of tracer gas leak testing. It can measure leaks as small as 1x10-10 std.cm3/sec.

This vacuum leak test uses a vacuum chamber to test the part. Air is evacuated from the chamber and from inside the part, and when the vacuum level stabilizes, the mass spectrometer or residual gas analyzer measures the baseline level of the tracer gas.

To begin the actual test, the part is pressurized with helium. The level of helium in the chamber is then monitored throughout the test. If the amount of helium exceeds the preset threshold, it means the part failed.

A hard vacuum test can be inside out or outside in:

- **An inside-out test** fills the test part with helium and measures the amount of gas leaking into the vacuum chamber.
- **An outside-in test** floods the chamber with helium and measures the amount of gas that leaks into the sealed part under test.

A hard vacuum test provides reliable repeatability, fast cycle times

ADVANTAGES

- ✔ Reliable repeatability.
- ✔ Fast cycle times.
- ✔ High leak detection accuracy and reduced false-leak failures.
- ✔ Extreme sensitivity to detect leaks up to 1 x 10-8 scc/s.

COMPONENTS OF A HARD VACUUM TEST:

- A vacuum chamber or device.
- A pump to evacuate the atmosphere in the chamber.
- A mass spectrometer to measure the mass of helium around the part.
- A sniffer that can be added to aid in locating leaks.

IDEAL FOR TESTING SPECIFIC TYPES OF HVAC/R COMPONENTS, SUCH AS:

- Evaporator coil assemblies.
- Condenser assemblies.
- Compressor assemblies.
- Refrigerant line assemblies.

Part Three: Accumulation Leak Testers

Maintaining a high-vacuum chamber for leak testing can be challenging, especially with high-frequency operation requiring cycling between vacuum and atmospheric pressure as frequently as every 30 seconds. Accumulation testing offers a simpler, cost-effective approach.

An accumulation test uses a closed volume and measures the trace gas rate of rise over time. The rate of change in the amount of trace gas corresponds to the leak rate; the faster the concentration increases, the higher the leak rate.

The main challenge for manufacturers is that the system can decrease in sensitivity over time based on atmospheric background noise. The system calibration may have to be validated using a known leak introduced into the test sequence. You can also connect a "background leak" that you can measure at the end of each test to verify the integrity of the test environment.

ADVANTAGES

- ✓ It is less expensive than hard vacuum leak testing.
- ✓ It provides a leak rate using the rate of change in gas concentration.
- ✓ It can detect leaks of 0.5 grams per year of coolant loss or greater.

DISADVANTAGES

- ✗ It is affected by noise from atmospheric gases.
- ✗ Its sensitivity can decrease as background increases.
- ✗ It needs to be regularly calibrated and validated using a part with a known leak.

Part Four: Carrier Gas Testing

Unfortunately, accumulation tests take time and tend to be susceptible to atmospheric noise due to residual gas around the chamber. For better-controlled leak rate results, consider carrier gas testing—especially when testing smaller parts.

Rather than accumulating gas in the chamber, carrier gas tests run a stream of tracer gas through the chamber. The gas exiting the chamber is sampled to measure the amount of leak gas. From that, you can calculate the leak rate.

CARRIER GAS LEAK TESTS ARE USEFUL FOR:

- Testing refrigerant line connections, such as welds and brazed joints.
- Testing high-pressure line fittings

ADVANTAGES

- ✓ They provide real-time leak measurements.
- ✓ They can measure the leak rate.

DISADVANTAGES

- ✗ The test results can be affected by trace gases in the atmosphere.
- ✗ The sensitivity of the test system deteriorates as background increases.

Part Five: Nitrogen Purge Leak Test

Carrier gas testing can test larger parts if you can create a sealed environment. You need a well-sealed chamber to prevent contaminating the test with atmospheric air. Nitrogen purge leak testing eliminates the problem by isolating the test chamber.

Using tracer gas to test for leaks in pipe joints, tubes, and fittings is more challenging than testing individual parts because it is difficult to create an airtight seal. And conventional sniffer technology won't work to detect small leaks because there is too much atmospheric noise. So to test joints, you need a way to create a sealed chamber for leak testing.

Nitrogen purge testing addresses the problem by creating a trace-gas-free seal to isolate the test chamber. CTS has developed a purge clamshell device with inner and outer areas that surround the part test area. The ambient atmosphere is forced out of the chamber and replaced by nitrogen, creating a gas curtain around the joint or part.

NITROGEN PURGE LEAK TESTS ARE USEFUL FOR:

- Testing refrigerant line connections, such as welds and brazed joints.
- Testing high-pressure line fittings.

ADVANTAGES

- ✔ It can test any tube size.
- ✔ It uses a high-flow nitrogen curtain, meaning you don't need a tightly sealed test environment.
- ✔ It eliminates the problem of test contamination from atmospheric gases.

Part Six: Sniffer Leak Testing

Atmospheric Sniff Leak Testing is a basic method of tracer gas leak detection that uses a sniffer probe to detect the presence of tracer gas and pinpoint an area that is leaking.

During the sniff test process, a part or component is evacuated, and then filled with a tracer gas. A probe is then manually moved over the surface of the part to detect leakage. The sniffer probe draws in the air sample from around the part test area and into the mass spectrometer, where it is analyzed for tracer gas concentration.

Sniff leak locating is highly effective at sensing and locating micro leaks and is best suited for checking lower volumes of parts. It is often used after a failed gross leak test to determine the specific leak location.

SNIFFERS ARE USEFUL FOR LEAK LOCATION, SUCH AS:

- Testing subassembly joints and part connections.
- Testing final assemblies, including connection points.

ADVANTAGES

- ✔ They are portable and can be used to test for trace gas almost anywhere
- ✔ They make it easier to locate leaks in the field or large areas
- ✔ Low-cost tracer gas testing method that pinpoints the location of the leak
- ✔ Can detect leaks in the range of 1.6 x 10-1 to 1x10-5 scc/

DISADVANTAGES

- ✘ They are less precise than other tracer gas tests.
- ✘ They can only detect leaks greater than 0.5 grams/year of refrigerant loss.
- ✘ Work best in an environment that is well ventilated, free of trace-gas
- ✘ Effectiveness is limited in environments where background noise (air flow) reduces the concentration of the gas tracer
- ✘ As sniff leak detectors are typically operated manually, the reliability of the sniff test is dependent upon the experience of the operator.

Part Seven: CTS Solutions for HVAC/R Leak Test

There are many different tracer gas tests available for leak testing and choosing the right one depends upon your specific application. If you are hunting for smaller leaks—such as those that affect refrigeration and HVAC units—then you need to choose a test with the sensitivity to accurately measure those leaks. Also, consider the variables that affect your leak test and the most appropriate gas.

A flexible, automated solution for detecting microleaks

The TracerMate II is a leak test and tracer gas management instrument from Cincinnati Test Systems. With leak test know-how built into every system, the flexible TracerMate can be used for all types of tracer gas leak testing.

Learn more >

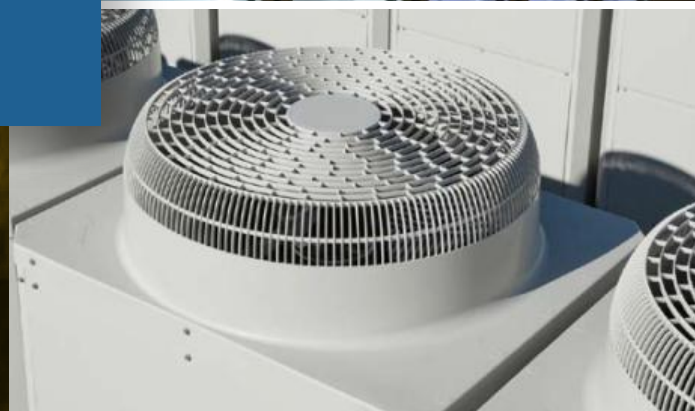
Turnkey Stations

CTS also offers turnkey stations such as an integrated, portable tracer gas leak location solution for HVAC and refrigerant systems.

Learn more >

CINCINNATI TEST SYSTEMS

Your Global Leak and Function Test Solution Experts



Choose the right test for your HVAC/R components

The experts at CTS can assist you in designing the right test for your HVAC/R manufacturing leak test application.

Contact us today >

cincinnati-test.com