Varian, Inc.
Vacuum Technologies

VS Series Leak Detectors for Vacuum Furnaces

Inspiring Excellence

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Introduction

All vacuum furnaces operate by controlling the gas environment within the chamber allowing certain transformations of the material to reach desired parameters. When a leak occurs, integrity of the material being processed can be compromised. Therefore, a leak tight system is paramount for consistent, accurate treatment of any material.

Application Description

Every vacuum furnace eventually develops leaks that might affect product quality and/or damage internal components. No matter what the type of furnace all must maintain a leak free environment to attain purity levels necessary for controlled reactions in the furnace. Those leaks can develop in multiple locations – valves, feedthroughs, door seals, etc. During process conditions, when temperatures are elevated, different metals expand at different rates sometimes opening up leaks that are not present at lower temperatures.

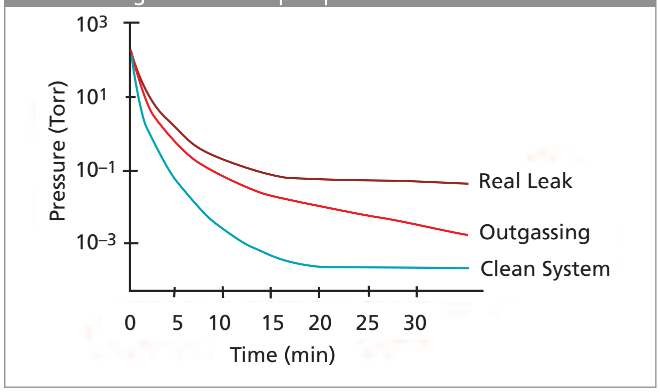
Large leaks in a vacuum furnace will be very obvious. In these cases, the furnace will not pump down and/or the treated material will show clear signs of oxidation. Small leaks however often go undetected, as the pumping system can easily offset the gas load of the leak. As a result the vacuum gauge(s) might still show adequate levels misleading the system operators, however, small leaks can result in major damage and scrap depending on the application or process.

Alternative Leak Detection Methods

Observe the Pump Down Cycle

Compare the furnace pump down cycle with a previous cycle made when the system was in a good working order. Evaluation of the pressure vs. time curve, like the example shown in Figure 1, can indicate the presence of a leak. If the vacuum level is slow to reach the original base pressure, then outgassing is suspected. Outgassing is simply additional gas load and can come from a variety of sources. With outgassing the system pressure will decrease, albeit more slowly than normal. A real leak however will cause the pumpdown to stall at a higher than desired pressure.

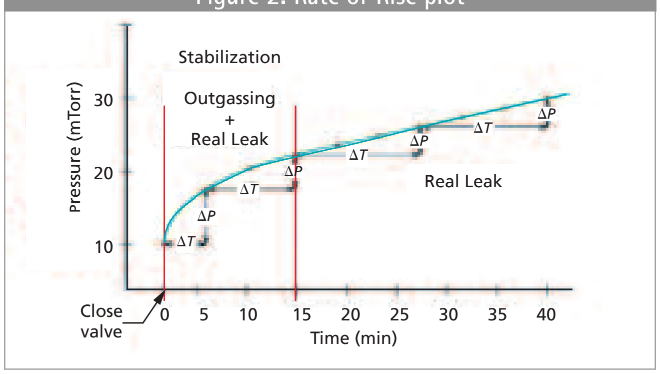
Fig 1. Chamber pumpdown characteristics



Perform Rate of Rise (RoR) Test

During this test the operator can close the valve between the vacuum pump and the chamber. This stops the evacuation process. After a short stabilization time, observe in Figure 2 the rise in pressure (ΔP) over time (ΔT) or, in other words, a vacuum decay.

Figure 2. Rate of Rise plot



Vacuum decay is the difference in the vacuum levels at the beginning and end of the measurement divided by elapsed time and can be measured quite accurately. In the industry, it is normally expressed in microns per hour. (For most vacuum applications, a vacuum decay exceeding 10 microns per hour is usually unacceptable).

Observing the pump down cycle and performing a rate of rise test are affected by the overall cleanliness of the furnace and might not lead to an immediate detection of the problems. Moreover, it will be quite difficult and time consuming to determine that the problems are caused by a leak in the vacuum system.

Rate of rise and vacuum decay tests will not locate leaks, they will only indicate the relative magnitude of all leaks combined.

Helium Leak Detection

Helium Leak Detection Benefits

Helium leak detection is truly the perfect solution to guarantee the tightness of a vacuum furnace.

Major advantages of helium leak detection technology:

- Ability to pinpoint the location(s) of the leak(s). *Benefit:* Spend less time making repairs.
- Allows quantifiable measurements. *Benefit:* Understand which leaks will cause problems.
- Outgassing issues do not affect the method. *Benefit:* Can test regardless of chamber condition.
- Can be performed quickly and can be a routine operation at the start of each production run. *Benefit:* Saves time and reduces scrap.

Why helium as a tracer gas?

Helium is present in only small amounts in the ambient air. This results in low background noise and makes helium a very attractive gas for leak detection applications. It is also:

- Readily available worldwide
- Non-toxic
- Non-flammable
- Totally inert

General Principle of Helium Leak Detection

Helium leak detection works as follows: Helium is applied to one side of a containing wall. Any helium that leaks through the wall is detected by a helium-tuned mass spectrometer.

While this is straightforward, test results can vary widely depending on where the leak detector is connected to the system. Hooking up the leak detector in the wrong location can significantly reduce its response time, sensitivity and ability to clean up a helium signal; even to the point of rendering it "blind" to leaks. To explain we'll define response time, sensitivity and clean up, then show how the location of the leak detector is affected by each parameter.

Response Time

Response time is the time required for a leak detector to yield a signal output equal to 63 percent of the maximum signal attained when helium is applied indefinitely to a leak location. Mathematically this is stated as:

$$t_{63} = \frac{V}{S}$$

Where: t = Time (seconds)
V = Volume (liters)
S = Helium pumping speed (liters/second)

Larger volumes will have a longer response time than smaller volumes and systems with higher pumping speed will have faster response times than systems with lower pumping speed.

Clean up Time

Once a leak is found, the helium that leaked into the system must be pumped away in order to continue testing. As with response time, clean up is a function of volume and helium pumping speed of the system and leak detector pumps.

Sensitivity

Clearly response time and clean up will benefit if the rough and high vacuum pumps are operating during the helium leak test. However, their high pumping speed means that a good portion of the helium signal will be pumped away since the pumping speed of the leak detector is considerably less. So sensitivity is lost when large pumps are used.

Situating the leak detector in the Vacuum System

For a discussion on the three common locations to attach a leak detector to a vacuum furnace, refer to Figure 3.

The Varian Solution

Leaks found in vacuum furnaces typically fall in the mid-range of a helium leak detector's sensitivity and therefore are not particularly challenging from a detection standpoint. However, Varian's VS series leak detectors possess unique capabilities that can save money, and simplify and speed up the leak testing process.

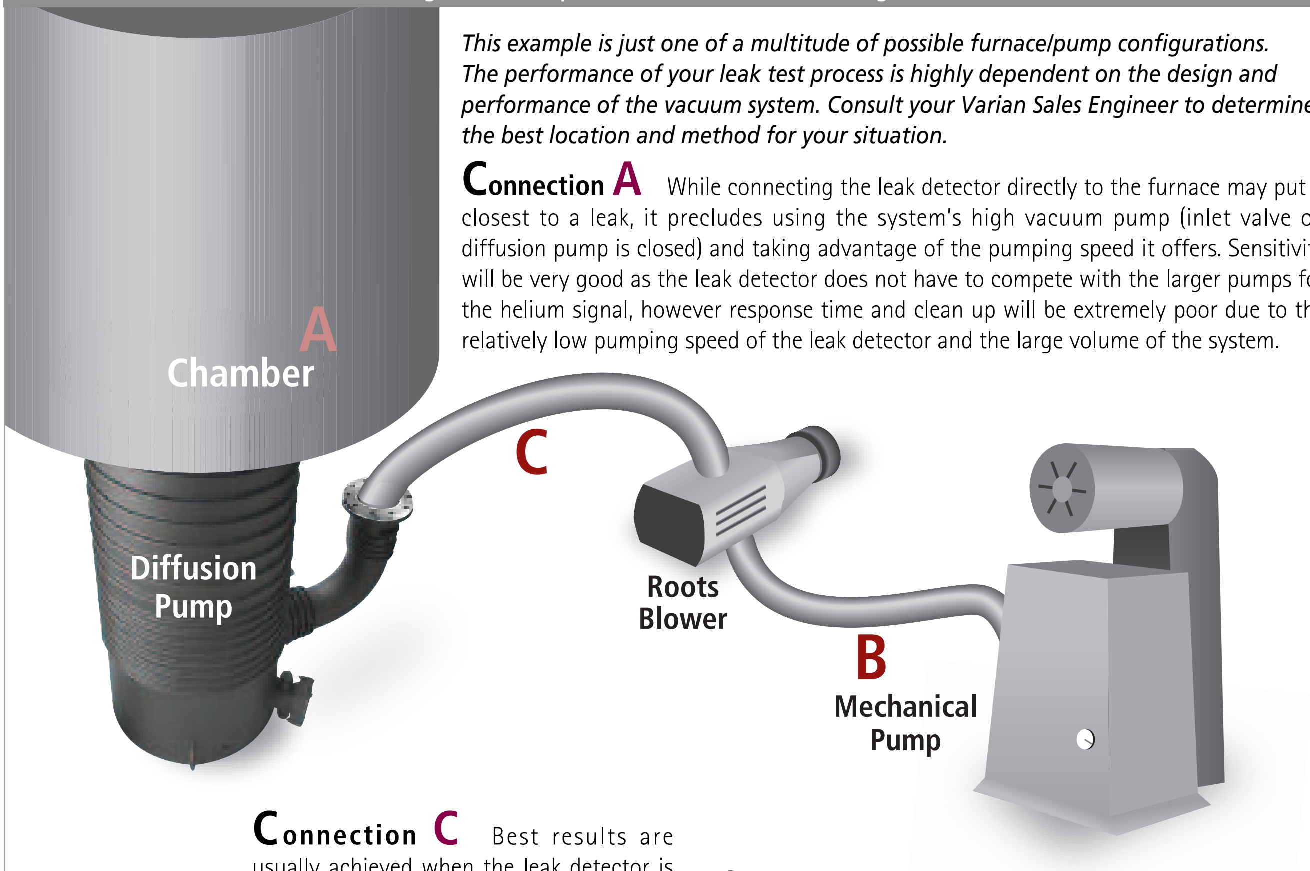
Finding Large Leaks

Occasionally a very large leak will prevent a furnace from reaching the vacuum level necessary for the leak detector to begin testing (typically less than 10 Torr). The result is time wasted tightening fittings, cleaning seals, re-checking valves, etc. Some manufacturers address this by adding auxiliary pumps that add to expense and bulk. A VS leak detector offers a special large leak indicator that operates at pressures as high as 150 Torr taking the guesswork out of finding the leak.

Figure 3. Example leak detector/furnace configuration

This example is just one of a multitude of possible furnace/pump configurations. The performance of your leak test process is highly dependent on the design and performance of the vacuum system. Consult your Varian Sales Engineer to determine the best location and method for your situation.

Connection A While connecting the leak detector directly to the furnace may put it closest to a leak, it precludes using the system's high vacuum pump (inlet valve on diffusion pump is closed) and taking advantage of the pumping speed it offers. Sensitivity will be very good as the leak detector does not have to compete with the larger pumps for the helium signal, however response time and clean up will be extremely poor due to the relatively low pumping speed of the leak detector and the large volume of the system.



THREE COMMON LOCATIONS TO ATTACH A LEAK DETECTOR TO A VACUUM FURNACE

Connection C Best results are usually achieved when the leak detector is connected to the foreline of the high vacuum pump, or just above the inlet of the blower. In this position the pumping capacity of the system's high vacuum pump offers excellent response time and clean up, and the blower greatly reduces helium background and oil backstreaming. Sensitivity is somewhat less due to the pumping speed of the blower, but this can offset by trapping helium around the leak location (bagging) or adjusting the leak detector to compensate for the loss.

Connection B In B the leak detector is between the blower and mechanical pump. Response time is very good because you're taking advantage of the high helium pumping speed of the high vacuum pump and blower. Since the helium pumping speed for the mechanical pump is less than the blower, less helium is lost and sensitivity is good. But because mechanical pumps do a poor job of pumping helium, clean up suffers. Once a leak is found helium can be trapped in the mechanical pump creating a high background signal that impedes further testing. Connections close to the mechanical pump can also be somewhat dirty due to oil backstreaming from the pump.

Sensitivity Compensation

To compensate for the helium lost to high speed pumps Varian offers a Split Flow adjustment on its leak detectors. This capability means that leaks can still be read accurately even when the leak detector is coupled to a system with large pumps.

Data Analysis & Storage

Varian also offers PC-based Leak Test Data Wizard software. This easy to use program gives the user the ability to control the leak test process and log the results.

Software features:

- Pump down data (Figure 4)
- Rate of Rise plots
- Store test results and maintain product traceability
- Perform statistical analysis (Figure 5)
- Export data to Excel for further analysis

Figure 4. Leak Test Data Wizard, Chamber Pumpdown

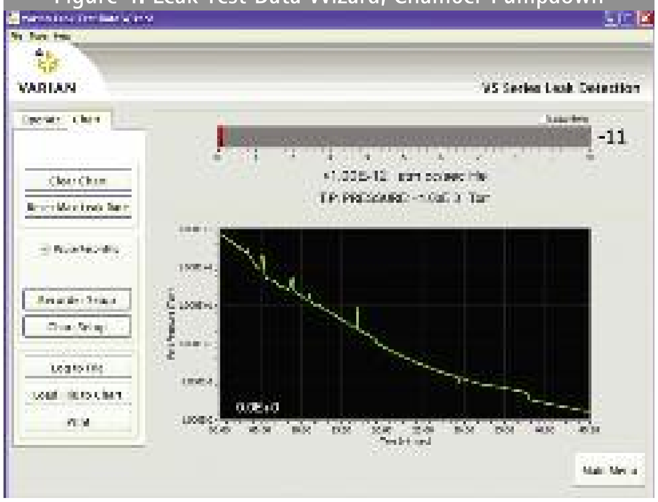
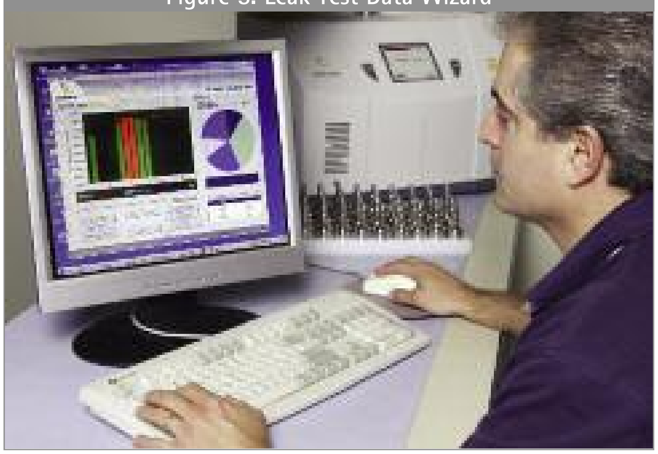


Figure 5. Leak Test Data Wizard



Wireless Hand-held Remote

Given the size and configuration of many vacuum furnaces, the operator may be spraying Helium a considerable distance from the leak detector and is therefore unable to see or hear the instrument respond to Helium. Wired remote controls have sought to address this problem, but impedance and the cumbersome nature of long cables are often limiting factors. The VS' wireless hand-held remote control allows leak testing up to 100 meters from the base unit, Figure 6. All the major functions of the leak detector are at your fingertips, the display has a bar graph of the leak rate, and a speaker provides a variable tone indicating the trend and relative size of the leak. Large systems, in which two technicians were previously required, can now be tested by one technician, thereby reducing labor costs.

Figure 6. Using the wireless remote

Support & Service Organization

Finally, the proper selection of a detector, the connection of the detector to the furnace and the appropriate use of helium tracer gas are fundamental to the overall performance and success of the helium leak test process on a vacuum furnace. Our highly trained and experienced sales and service team will be pleased to guide you though the selection process and all operational issues.

With offices worldwide, Varian can easily support manufacturing and customer sites around the globe. This level of support is reflected in the VS interface which can be displayed in seven different languages.

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