

Varian, Inc.  
Vacuum Technologies



## VS Series Leak Detectors for Vacuum Furnaces

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 Agilent Technologies

# VS Series Leak Detectors for Vacuum Furnaces



## 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.

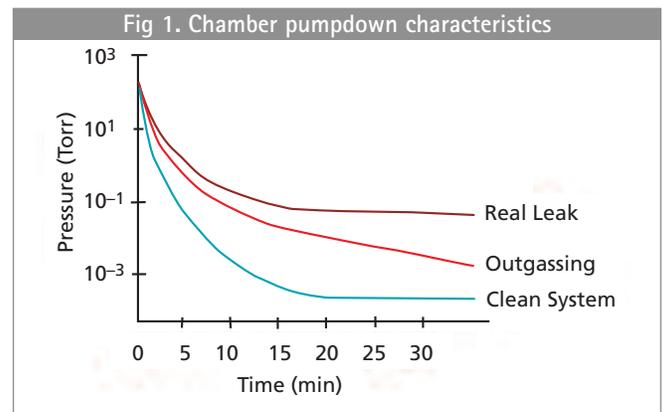
Large leaks in a vacuum furnace will be very obvious. In these cases, the furnace will not pump down and/or the treated material will show clear signs of oxidation. Small leaks however often go undetected, as the pumping system can easily offset the gas load of the leak. As a result the vacuum gauge(s) 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

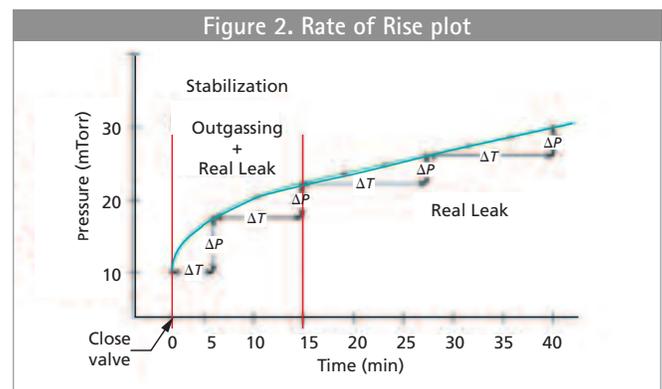
Compare the furnace pump down cycle with a previous cycle made when the system was in a good working order. Evaluation of the pressure vs. time curve, like the example shown in Figure 1, can indicate the presence of a leak. If the vacuum level is slow to reach the original base pressure,

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.



### 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 ( $\Delta P$ ) over time ( $\Delta T$ ) or, in other words, a vacuum decay.



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.

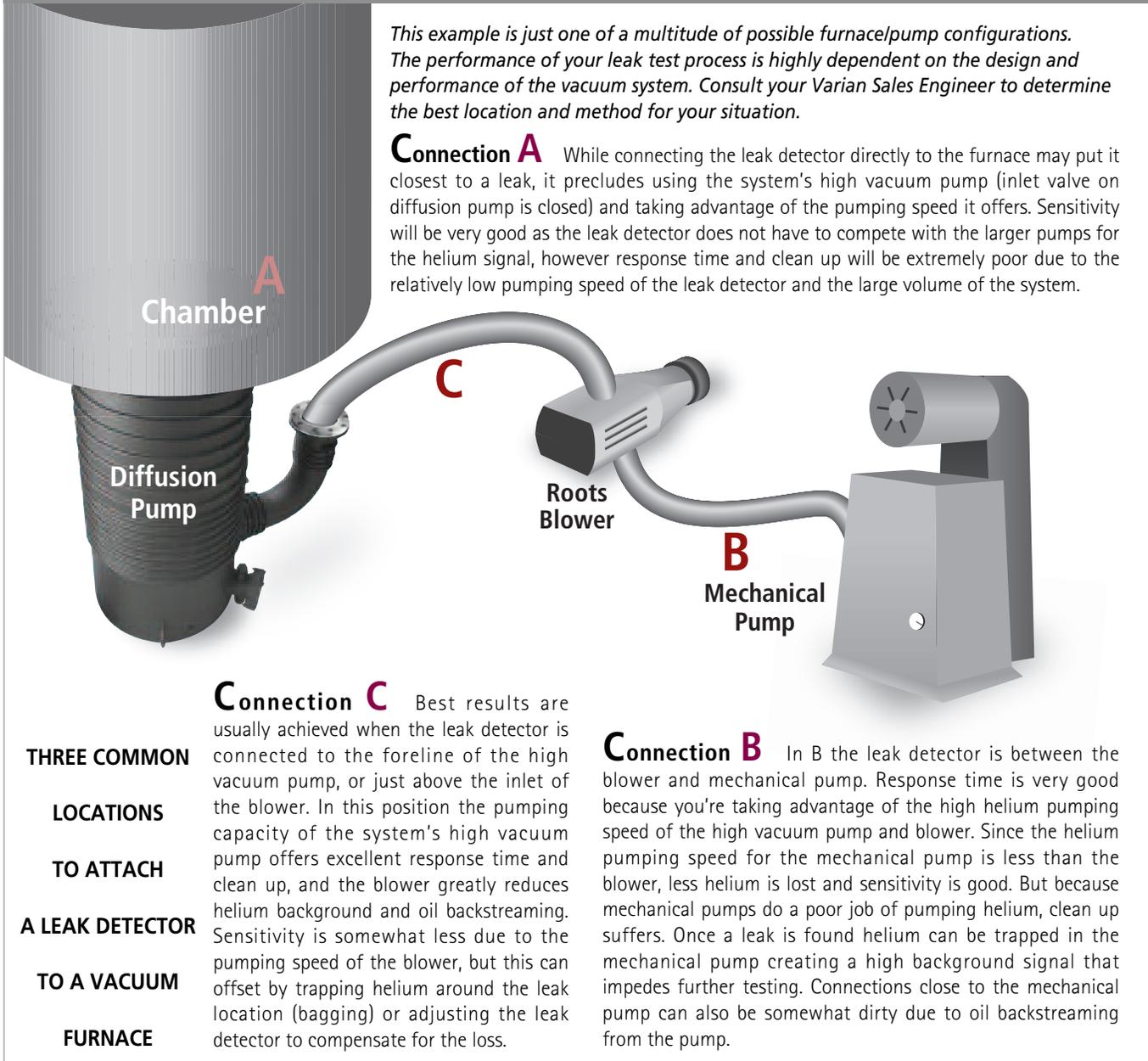
### The Varian Solution

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



### 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.

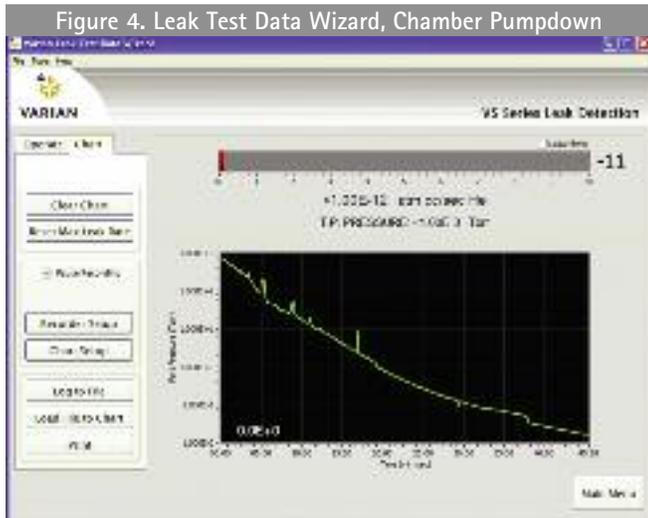
### Data Analysis & Storage

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

# VS Series Leak Detectors for Vacuum Furnaces



## 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.

## 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 through 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.

# Varian, Inc. Vacuum Technologies

## Canada

Central coordination through:  
Varian, Inc.  
121 Hartwell Avenue  
Lexington, MA 02421  
USA  
Tel: (781) 861 7200  
Fax: (781) 860 5437  
Toll Free: 1 (800) 882 7426

## China

Varian Technologies – Beijing  
Rm 1648 Central Tower South Wing  
Beijing Junefield Plaza  
No. 10 XuanWuMenWai Street  
Beijing 100052  
P.R. China  
Tel: (86) 10 63108550  
Fax: (86) 10 63100141  
Toll Free: 800 820 6556

## France and Benelux

Varian s.a.  
7 avenue des Tropiques  
Z.A. de Courtaboeuf – B.P. 12  
91941 – Les Ulis cedex  
France  
Tel: +33 (0) 1 69 86 38 84  
Fax: +33 (0) 1 69 86 29 88  
From Benelux Tel: (31) 118 67 15 70  
From Benelux Fax: (31) 118 67 15 69

## Germany and Austria

Varian Deutschland GmbH  
Alsfelder Strasse 6  
Postfach 11 14 35  
64289 Darmstadt – Germany  
Tel: (49) 6151 703 353  
Fax: (49) 6151 703 302

## India

Varian India PVT LTD  
101-108, 1st Floor  
1010 Competent House  
7, Nangal Raya Business Centre  
New Delhi 110 046 – India  
Tel: (91) 11 28521171  
Fax: (91) 11 28521173

## Italy

Varian, Inc.  
via F.lli Varian 54  
10040 Leini, (Torino) – Italy  
Tel: (39) 011 997 9 111  
Fax: (39) 011 997 9 350

## Japan

Varian Vacuum Technologies  
Sumitomo Shibaura Building, 8th Floor  
4-16-36 Shibaura  
Minato-ku, Tokyo 108 – Japan  
Tel: (81) 3 5232 1253  
Fax: (81) 3 5232 1263  
Toll Free: 0120 655 040

## Korea

Varian Technologies Korea, Ltd  
Shinsa 2nd Bldg. 2F  
966-5 Daechi-dong  
Kangnam-gu, Seoul – Korea 135-280  
Tel: (82) 2 3452 2452  
Fax: (82) 2 3452 2451  
Toll Free: 080 222 2452

## Mexico

Varian, S. de R.L. de C.V.  
Concepcion Beistegui No 109  
Col Del Valle  
C.P. 03100 – Mexico, D.F.  
Tel: (52) 5 523 9465  
Fax: (52) 5 523 9472

## Taiwan

Varian Technologies Asia Ltd.  
14F-6, No.77, Hsin Tai Wu Rd., Sec. 1  
Hsi chih, Taipei Hsien – Taiwan, R.O.C.  
Tel: (886) 2 2698 9555  
Fax: (886) 2 2698 9678  
Toll Free: 0800 051342

## UK and Ireland

Varian Ltd.  
6 Mead Road  
Oxford Industrial Park – Yarnton  
Oxford – UK  
Tel: +44 (0) 1865 291570  
Fax: +44 (0) 1865 291571

## United States

Varian, Inc.  
121 Hartwell Avenue  
Lexington, MA 02421  
USA  
Tel: (781) 861 7200  
Fax: (781) 860 5437

## Other Countries

Varian, Inc.  
Vacuum Technologies  
via F.lli Varian 54  
10040 Leini, (Torino)  
Italy  
Tel: (39) 011 997 9 111  
Fax: (39) 011 997 9 350

**Toll Free Number for North America**  
1 (800) 882 7426

**Toll Free Number for Europe**  
00 800 234 234 00



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