APPLICATION NOTE LD02
February 2006

VARIAN

Detecting Leaks in Vacuum Furnaces

All vacuum furnaces, whether they are hot zone, ion carburizing, or low pressure carburizing types, require the maintenance of a leak-free environment in order to control the transformation of materials to meet strict product quality requirements. Unfortunately, every vacuum furnace will eventually develop leaks that can compromise the integrity of the material being processed. Leaks can also damage internal furnace components. This explains why a leak-tight system is so critical to achieving consistent and accurate treatment of any material within a furnace chamber.

Different metals in the furnace expand at different rates when the furnace is in operation, sometimes opening up leaks that are not present at lower temperatures. Such leaks can develop in multiple process gas entries, valves, feedthroughs, and door seals. Large leaks in a vacuum furnace will be very obvious. The furnace will not pump down or the hot zone will show clear signs of oxidation. Small leaks, however, often go undetected, because the pumping system can easily offset any leak impact. System operators may be misled by gauge readings that still show adequate vacuum levels. But even such small leaks can result in major problems, especially in the most critical applications.

Comparing pump down cycle

A relatively simple leak detection method is to compare the pump down cycle with a previous cycle made when the system was in a good working order (see next page for graph comparing pumpdown cycle). If the vacuum level improves with each successive pump down, then outgassing should be suspected. Outgassing can also be detected in large vacuum furnaces when large pressure spikes occur or when pressure rises during the heating portion of process cycle.

Performing vacuum decay measurement

Another simple leak detection method involves performing a vacuum decay measurement (see next page for vacuum decay measurement graph). This test is accomplished by closing the valve between the vacuum pump and the chamber, stopping the evacuation process. After a short stabilization time, the pressure can be observed to look for a pressure rise or vacuum decay. The vacuum decay rate is defined as the difference in the vacuum levels at the beginning and the end of the measurement divided by the elapsed time. It is normally expressed in microns/hour. For most

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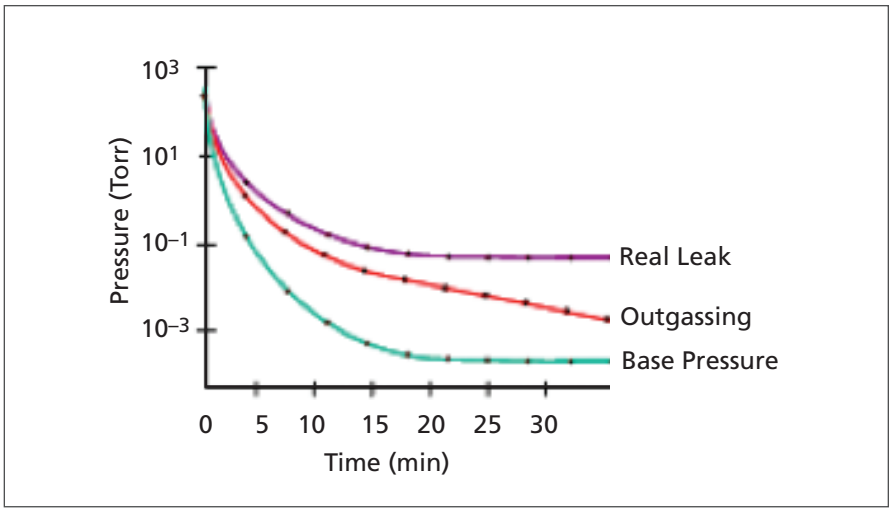
vacuum applications, a vacuum decay rate above 10 microns/hour in the heating chamber is unacceptable.

Both of these methods are affected by the overall cleanliness of the furnace. To properly perform a vacuum decay test, the furnace must be clean, cold, empty, and out-gassed to obtain a true leak-up rate value. If it isn't, a conditioning cycle should be run. This is a time-consuming process that normally involves heating the equipment to 50°F-100°F (30°C-55°C) higher than the furnace's normal operating temperature for 2 to 4 hours. Then a vacuum is drawn and the furnace is cooled overnight. It's important to note that a vacuum decay test determines the existence of a leak and quantifies its magnitude but does not identify its location.

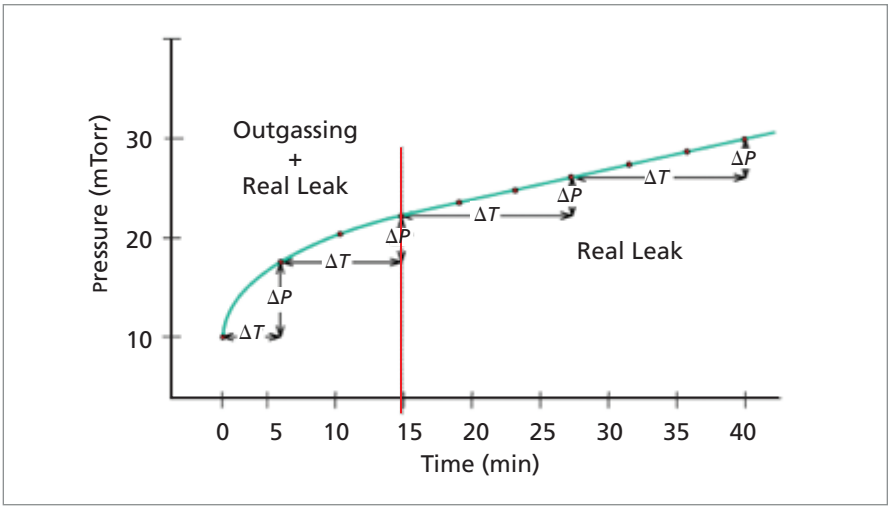
Helium leak detection

Helium leak detection is the most powerful method of validating the integrity of a vacuum furnace. Helium makes an ideal tracer gas because it is present in only small amounts in the ambient air. This results in low background noise. In addition, helium is readily available on a worldwide basis, is not toxic, flammable or reactive. It offers major advantages over other leak detection methods such as the ability to pinpoint the location of leaks and not being affected by outgassing. In addition, helium leak detection is so fast that it can easily be performed as a routine operation at the start of each production run.

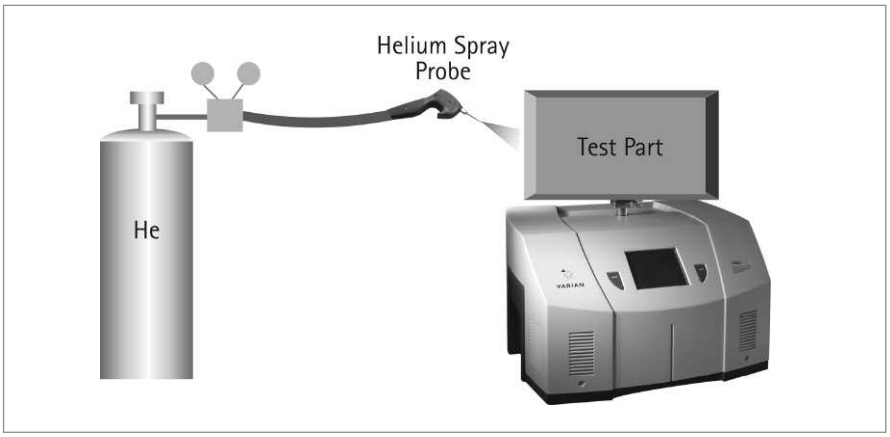
Helium leak detection works as follows. Helium is applied to one side of a containing wall. Any helium that leaks through the wall is measured by a helium-tuned mass spectrometer. The



Comparing pumpdown cycles

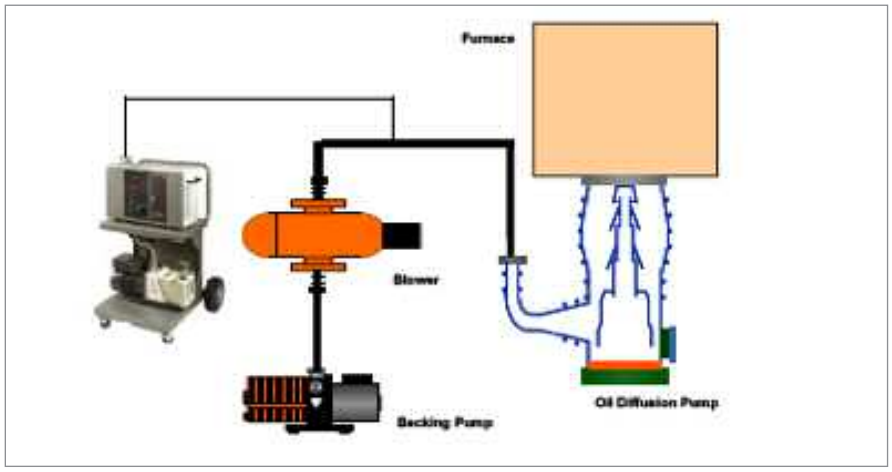


Performing vacuum decay measurement



Helium leak detection

high amount of helium released by a leak relative to low ambient levels mean that only a medium-sensitivity instrument is required to detect a leak. For this reason, moderately-priced equipment performs just as well in this application as high-performance detectors with sophisticated amplification systems that drive up both initial and maintenance costs.



Helium leak detection arrangement on a furnace

It's important to note that most vacuum furnaces are not considered clean by vacuum standards, so it is important to select only helium leak detection equipment tailored to industrial applications as opposed to those designed for laboratory use. The leak detector must be able to withstand operation in an environment containing oil and water vapors and, to provide the reliability required for production operations, must be resistant to mechanical vibrations.

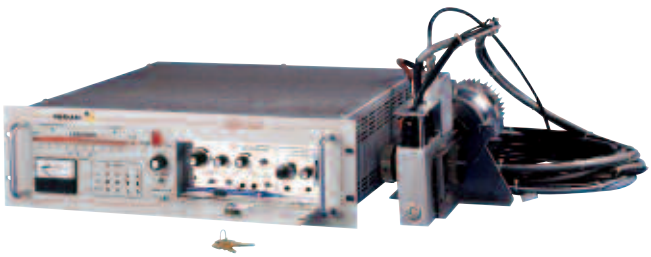
Leak checking a door assembly

Varian Inc.'s vacuum technologies provides and supports a full line of helium leak detectors tailored to the most demanding industrial applications. These systems provide a level of sensitivity and performance that exceeds the needs of vacuum furnace users at a very reasonable cost. Varian is continuously working to improve the ability of its helium leak detectors to deliver the sensitivity and reliability required in vacuum furnace applications.

A helium mass spectrometer is the ideal tool to identify and pinpoint leaks in a vacuum furnace. The selection of a detector, the connection of the detector to the furnace, and the proper use of helium tracer gas are fundamental to the overall success of the helium leak test process. This application note is designed to provide only general guidelines. Our highly trained and experienced sales and service team will be pleased to work with you throughout the selection and implementation process to ensure the success of your application.

Varian VS Series with Scroll Pump

Varian 959 with Rotary Vane Pump



Varian 990 dCLD for permanent integration in a furnace

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