TELEDYNE HASTINGS INSTRUMENTS
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Optimizing Load-Lock Operations

How can Better Pressure Measurement Improve the Operation of Your Load-Lock?

The primary purpose of a load-lock system is to transition from an ambient condition to a vacuum process condition. Consequently, the more accurately it achieves these two specific pressure environments, the greater the improvement in process quality and efficiency. For this reason, measuring pressure effectively at these two levels is critical to the proper operation of a load-lock. At ambient pressure, when the load-lock is opened to the industrial environment and handler, it is ideal to have a slightly positive relative pressure to reduce the flow of contaminated, humid air into the load-lock. However, if the load-lock pressure is too high, it can cause a symptomatic “popping” sound as a burst of gas exits the load-lock, which leads to a variety of associated process issues. To determine the venting endpoint, precise measurement of near-atmospheric pressure is required so that the load-lock is opened only when it has been sufficiently vented.

As the load-lock reaches transfer pressures in the mTorr range, precise pressure measurement is again critical to its performance. If the instrument used for measurement reads too high, the actual load-lock pressure will be lower than necessary when the transfer occurs. This situation ultimately results in wasted time (and process throughput) as the load-lock chamber remains in the pumping phase longer than necessary. Conversely, if the instrument reads too low, the actual load-lock pressure will be too high when the transfer valve is opened, causing contaminants to migrate and compromise the purity of the process environment.

Historically, several approaches to accomplish load-lock pressure measurement have been used. One approach employs a convection-enhanced Pirani vacuum gauge to measure both pressure regions. While this type of gauge functions relatively well for the low-pressure transfer, it has significant issues at the vent pressure condition due to response time, gas type, gauge orientation (attitude) and temperature. A second approach involves using a mechanical force-based pressure switch for the vent pressure indication; however, this technology has inherent variability which creates over-pressure or under-pressure events. Using two properly selected, separate gauges is effective, but requires additional electronics, interfaces and vacuum connections. Given these considerations, the ideal solution to load-lock pressure measurement is the combination of two sensors, each designed for a specific range, in a single instrument.

Objectives

- Ensure proper load-lock venting and transfer pressure conditions
- Avoid “popping” events when opening the load-lock
- Reduce contaminant transport during the process

Method

Proper load-lock operation requires accurate measurement at both ambient (atmospheric) vent pressure and again at transfer pressure in the mTorr range. Additionally, pressure measurement between these regions is useful for diagnostic purposes, but it is not critical to the function of the load-lock.

When considering the vent to atmospheric pressure, the load-lock pressure must be above ambient pressure (typically by a few Torr) to provide the proper condition for opening the load-lock door. Pressure switches based on mechanical linkages, springs and contacts cannot achieve the required level of precision and often allow the door to open before the load-lock has attained positive relative pressure. To compensate for the variability of mechanical switches, some systems add a “wait period” to ensure the load-lock chamber has vented sufficiently. However, this practice causes an unnecessary delay and can often produce too much positive pressure.

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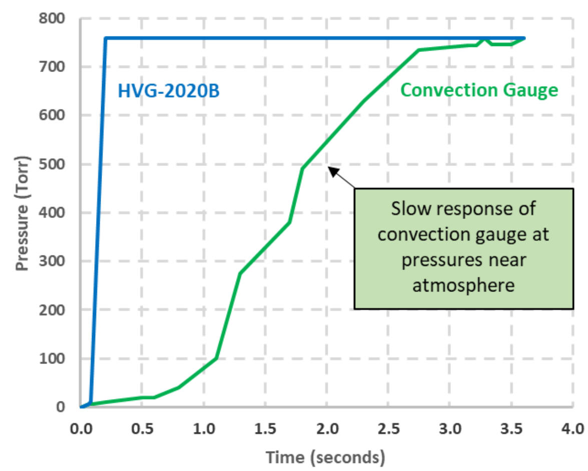
Figure 1 Load-Lock Vent to ATM: HVG-2020B vs Convection Pirani



Similar issues occur when controlling the load-lock using a convection-enhanced Pirani vacuum gauge (sometimes called a "convection gauge"). While this type of gauge is capable of providing a measurement at atmospheric pressure, the accuracy can be quite poor due to the many factors that adversely affect the signal. Being an indirect measurement of pressure, this gauge obtains its reading through the cooling of a hot wire by the gas's natural convection. While pressure does affect the convection cooling, other variables can have a significant impact on the sensor wire. These often include gas type, ambient temperature and orientation of the wire (attitude). Additionally, using a convection-enhanced Pirani gauge to monitor venting conditions slows process efficiency due to the time required to stabilize the convection currents around the sensor wire before measurement. Figure 1 shows this dramatic effect as the load-lock is rapidly vented to atmospheric pressure and gauge response lags, resulting in over-pressure during venting.

The best technique for measuring load-lock pressure requires two-sensor technologies, each designed for the specific needs of the two distinct functions of the load-lock. The vent pressure measurement is best accomplished by a direct measurement sensor technology that measures the force applied to a protective diaphragm, which in turn applies pressure to a Piezoresistor. This eliminates effects caused by variables such as gas type, temperature and gauge orientation. When the load-lock door is open, the sensor output is recorded by the system as the ambient pressure for the subsequent vent cycle. In this way, slow changes in the ambient condition (typically due to weather or the building's environmental control) are accommodated. Because a diaphragm-protected Piezoresistive sensor set for atmospheric pressure is incapable of also providing sufficient resolution at the mTorr level, a thermocouple-based or Pirani-based vacuum gauge is typically combined with the direct measurement sensor to precisely measure the transfer operation pressure. Finally, it should be mentioned that while employing two completely separate gauges may be technically superior, the inconvenience of each gauge having their own vacuum ports, cables and electronics is both impractical and undesirable. Consequently, the use of multi-sensor instruments that address the two measurement regions effectively in a single device, has become the precedent for load-lock applications.

Instrument Choice

Figure 2 HVG-2020B

The Teledyne Hastings' HVG-2020B is our single-instrument solution for load-lock applications, combining a diaphragm-protected Piezoresistive sensor and a thermal-based, hot-wire Pirani sensor, in one compact device. For determination of the load-lock venting endpoint, the Piezo sensor produces a rapid (100 msec) and accurate (0.1% Rdg + 0.3 T) response at atmospheric pressure that is gas type independent. To sense load-lock transfer pressure, the precision welded, hot-wire Pirani sensor accurately measures the mTorr range to ensure minimal process contamination. The HVG-2020B's integrated electronics includes two setpoints and produces a continuous pressure signal over the range between the two critical load-lock pressure regions. The HVG-2020B is a proven design for load-lock applications and has demonstrated its superior accuracy, functionality and reliability in numerous installations for many years.

For Information on all Teledyne Hastings Vacuum Measurement and Mass Flow Instruments, visit our website:

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