AGILENT TURBOMOLECULAR PUMPS MEASUREMENT METHODOLOGY
Agilent Vacuum Products: Our Commitment to Quality

Agilent’s commitment to quality and Measurement’s philosophy

Reference Standards (PNEUROP, ISO)

Agilent ETM Environmental Test Methodology

Methodology used during measurements (Pumping speed/Compression/Ultimate pressure)

Agilent Depts. in charge of measurements (Instruments calibration, metrology)

Agilent Turbomolecular Pumps Measurement Methodology
Quality is of paramount importance to Agilent. The Agilent mission is to strive to obtain the ‘Best In Industry’ product quality through a series of strict tests.

The Agilent Vacuum Product Division (VPD) reflects this philosophy and make sure that every released product is in compliance of the quality standards and also to the internal ETM Agilent standards and methodology.

The vacuum performance measurements applied to turbomolecular pumps are regulated by the following standards:

- ISO 5302:2003(e) Vacuum Technology – Turbomolecular pumps – Measurement of performance characteristics, equivalent to PNEUROP 5608

The vacuum performances tests applied to the Turbo molecular pumps are:

- High Pressure Pumping Speed for Argon, Helium, Hydrogen and Nitrogen
- Low Pressure Pumping Speed for Argon, Helium, Hydrogen and Nitrogen
- Compression Ratios for Argon, Helium, Hydrogen and Nitrogen
- Ultimate pressure
The Agilent commitment to technology leadership translates into quality, reliability and performance; our products need to comply with strict criteria, to make sure we can meet the most stringent customer expectations.

This development includes a broad range of tests and analyses, performed to ensure the highest levels of performance and reliability.

Through the ETM tests, Agilent VPD verifies, step by step, product performance and robustness in order to release a Reliable and High Quality product in line with the Agilent Standard, and ready for our customers’ demanding specifications.

- Shock Test
- Temperature Test
- Humidity Test
- Vibration Test
- Life Test
- Vacuum Test

See detailed Flyer for more information
Specific methods are used to get the most accurate measurement through the entire pressure range:

1. Test dome for Standard conductance method (for pressure <10^-6 mbar)

The method adopted for the measurements of the volume flow rate is known as “standard Conductance” in which a thin orifice divides the test dome (Fig.1) into two volumes.

Measuring the pressure in each of the two volumes with a gauge having the same sensitivity, the pumping speed is obtained by the following formula:

\[
S = C \cdot \left( \alpha \cdot \frac{P_1 - P_{10}}{P_2 - P_{20}} - 1 \right) \quad \text{and} \quad C = \sqrt{\frac{\pi \cdot R \cdot T}{32 \cdot M}} \cdot \frac{d^2}{1 + \frac{l}{d}}
\]

Where:

“C” is the calculated conductance taking account the orifice size and the gas properties. P10 and P20 are the base pressures in the two dome chambers (Fig.1) while the other is the pressure test.

where “M” is molecular mass of the gas, “T” is the absolute temperature in ° K, “d” and “l” are geometrical orifice parameters and “\( \alpha \)” is the relative calibration factor of the gauges.
2. Test for the throughput method (for pressure >10⁻⁶ mbar) for the throughput method (Fig.2)

Measuring the gas throughput “Q” flowing inside the test dome and the pressure “Pin” at the pump inlet, the pumping speed is given by the formula:

\[ S = \frac{Q}{P_{in}} \]

Remarks:

Pumping speed is measured for four different gases, Argon - Nitrogen - Helium - Hydrogen

- Curve refers to a sample of 5 different pumps under test.
- Measuring Uncertainties: A ±10% measurement error in accuracy, has to be considered. This is specified by the ISO21360-1 (2012-04) and the same measurement error is common to all manufacturers testing their pumps.
The Compression Ratio “K” is the ratio between the pressure (partial) at the pump exhaust and pressure (partial) at the inlet of the pump for a given process gas.

It is determined by flowing the process gas in the pump foreline with no gas injection into the test dome and so at the inlet of the pump.

The Compression ratio is obtained for the four major gases Ar, N$_2$, He, H$_2$. Measurements are recorded at three points per decade of the backing pressure.

\[
K = \frac{P_f - P_{f_0}}{P_i - P_{i_0}}
\]

\( P_f \) = Vacuum pressure in the backing line
\( P_{f_0} \) = Base Foreline Pressure
\( P_i \) = Inlet Pressure (measured)
\( P_{i_0} \) = Base inlet pressure

Remarks:

- Curve refers to a sample of 5 different pumps under test.
- Measuring Uncertainties: A ±20% measurement error in accuracy, has to be considered. This is specified by the ISO21360-1 (2012-04) and the same measurement error is common to all manufacturers testing their pumps.
The base pressure is measured in a leak-free test dome after 48 hours of bake-out through the Turbo pump fitted with ConFlat flange.

During the test the ambient temperature is in the range of 15-25°C

- A ±20% measurement error in accuracy has to be considered. This is specified by the ISO21360-1 (2012-04) and the same measurement error is common to all manufacturers testing their pumps.

**Reporting:**

Pumping speed and Compression Ratio are measured for four different gases: Argon - Nitrogen - Helium - Hydrogen.

A final report including all the tests results with information about instruments (pressure gauges, flow meter, etc.) used for the test is compiled by the Development Project Manager.

A copy of the report is filed in the project dossier following the ISO9000 standards.
Agilent Departments in charge of measures (competences, skills,...)

Instruments calibration and metrology

In order to achieve the highest quality of the products all departments in Agilent VPD are involved in the «quality» process and are required to pay the maximum attention to detail and dedication to their work.

In particular special attention is paid to the critical issue of instrument calibration to obtain the best performance and readings from every device used during the important step of qualification and measurement, of paramount importance for the Quality process.

To do so experienced and skilled Quality Technicians have the responsibility for both the calibration and verification of the instrumentation used to certify tests both in the R&D lab as well as on the production floor.

The control equipment and measuring devices involved in the monitoring of components is regulated by the internal procedure “Control tools and equipment” and it is applied both to those instruments controlled internally and those instruments controlled by third parties.

In case of calibrated measuring instruments, there is a calibration certificate in accordance with ISO/IEC 17025.

The frequency of calibration settings is typically 6 to 12 months unless there is an instrument malfunction.

In particular, the UHV and Capacitance gauge inspection is regulated by the internal procedure and verification frequency is 6 months for UHV and 12 months for Capacitance gauges (0.1/1 mbar).

Capacitive gauge above 1 mbar and flow meters are regularly sent to the control center for factory calibration.

Internal audits and calibration are regularly performed by authorized certification/calibration centers, such as the Spinning Rotor used for verifying the UHV and the Capacitance gauges for 0.1/1 mbar are certified by an authorized certification laboratory.