Leak rate measurements: from metrological laboratory to industry

Dr. M. Bergoglio
INRIM - Istituto Nazionale di ricerca metrologica
Strada delle Cacce 91, 10135 Torino, Italy

Abstract

In the semiconductor industry, vacuum, nuclear and aerospace technology reliable tightness measurements of the materials and components play a fundamental role on the performance and quality of products. Very small gas flows have to be measured in the field of environmental protection and personal safety. Depending on the requirement, small gas flows have to be delivered either with reference to vacuum (i.e. practically zero pressure) or to atmosphere (ambient pressure). Various types of leak artifacts are available as secondary standards: capillary-leaks, sintered metal-type leak with external gas supply or with rechargeable gas reservoirs. Such artifacts are calibrated against primary flow-meters to assure the correct traceability of the measurements performed.

An overview on different primary flow-meters designed and realized in several National Metrology Institutes for throughput measurements with reference to vacuum and with outlet to atmospheric pressure will be given. The standard flow-meters are essentially based on constant pressure-variable volume method. Other type of primary method consists in measuring the concentration rise of the tracer gas emitted by the leak inside a known volume; to measure the rise of the refrigerant gas concentration infrared techniques are used. The best standard uncertainties of NMIs flow-meters are ranging from 0.6% to 0.8% for molar flow from $1x10^{-9}$ mol/s ($2.5x10^{-6}$ Pa m^3/s) to 4 $x10^{-10}$ mol/s ($3.7x10^{-7}$ Pa m^3/s) and referred to atmospheric pressure. When the gas flow has to be delivered to vacuum the standard uncertainty lies in the range from 1.4% (at $4x10^{-13}$ mol/s, $9.7x10^{-9}$ Pa m^3/s) to 0.14% (at 10^{-6} mol/s, $1.5x10^{-4}$ Pa m^3/s).

Today, several methods of leak testing are available that include a variety of technology from a simple to highly sophisticated one. To take a good decision the advantages and the limitations of the various methods must be well known and compared. A discussion on the general leak test requirements will be given together with an analysis of the differences between the available test methods and the proper leak detection technique that has to be chosen. Finally, preliminary theoretical studies on metrological characteristics of the standard leaks are compared with the experimental results.