1. Scope

I. This Technical Guideline (TG) defines vacuum technical acceptance specifications concerning quantitative leak detection techniques to be used for ultra-high vacuum (UHV) chambers, components as well as large-volume vacuum tanks.

II. This document is not related to any other purpose as aforementioned.

2. General Requirements

I. **Leak detection equipment and personnel:** Leak detection equipment, including any necessary additional assemblies required, must be provided by the Contractor. Both leak check and leak rate measurements may only be carried out by well-trained, experienced and qualified personnel. The required start-up time of the leak detector must be observed. A start-up time of at least **1 h** is recommended. The use of dry (i.e. oil-free) leak detector equipment is mandatory. Leak detection sniffing techniques are not applicable and are not allowed.

II. **Documentation:** The entire leak detection procedure and leak detection setup must be documented in detail in the acceptance test protocol.

III. **Leak detection test gas:** Only **^{4}He** may be used to carry out any leak detection measurements.

IV. **Calibration of the leak detector:** Prior to any leak rate measurements, the leak detector must be calibrated using a calibrated He test leak according to appropriate specifications (e.g. according to (DIN) EN 13192). A test leak with a constant leak rate of **$\leq 1 \cdot 10^{-8}$ mbar·ℓ/s** is recommended. The calibration procedure shall be carried out according to the specifications of the manufacturer. Typically, an automatic calibration of the leak detector using an integrated internal calibrated test leak must be carried out. Alternatively, the calibration may be carried out with an appropriate external calibrated test leak. To correct for any instabilities or drifts of the leak detector, the leak detector must be recalibrated prior to each leak rate measurement according to the specifications of the manufacturer.

V. **Ambient conditions:** Both calibration and leak rate measurement are to be carried out under typical room temperature conditions, i.e. 20°C ... 23°C. In general, leak rate measurements in subcooled or overheated environments with large temperature fluctuations are to be avoided.

VI. **Volatile solvents:** No volatile solvents (e.g. ethanol, acetone, isopropanol) may be used to perform any (preliminary) leak tests.

VII. **Ultimate pressure and He background:** Leak detection measurements may only be carried out after a stable ultimate pressure in the vacuum chamber or component is reached. The He background must be as low as possible and must be documented for each individual leak measurement. An internal flushing of the pumping system with dry N_2 is recommended in order to prevent He backstreaming from the pumps.

VIII. **Leak rate:** If not otherwise stated, the He leak rate must be **≤ 1 · 10^{-10} mbar·ℓ/s**. The detection limit of the leak detector must be **≤ 1 · 10^{-11} mbar·ℓ/s**. During the entire measurement, He must be applied **continuously** (i.e. no intermittent He application is allowed). The duration of the leak rate measurement must be long enough so that a stable leak rate reading is possible.

IX. **Response time and time constant:** In order to guarantee leak detection with reliable leak rates, the leak test must be adapted to each individual vacuum chamber or component to be tested. The response time is defined as the time until the leak detector indicates the final leak rate value of the leak (100%). The time constant τ of the volume V_0 of the object under test is the response time after the leak rate reaches 63% (= 1 - e^{-1}) of the final leak rate value. It is defined as $\tau = V_0/S_0^{\mathrm{He}}$, where S_0^{He} is the pumping speed for He (usually specified by the manufacturer). After 3τ (three time constants) the leak rate must reach 95% of its final value (see Fig. 1). During the entire leak rate measurement, He must be applied **continuously** for a time of at least 3τ (three time constants).

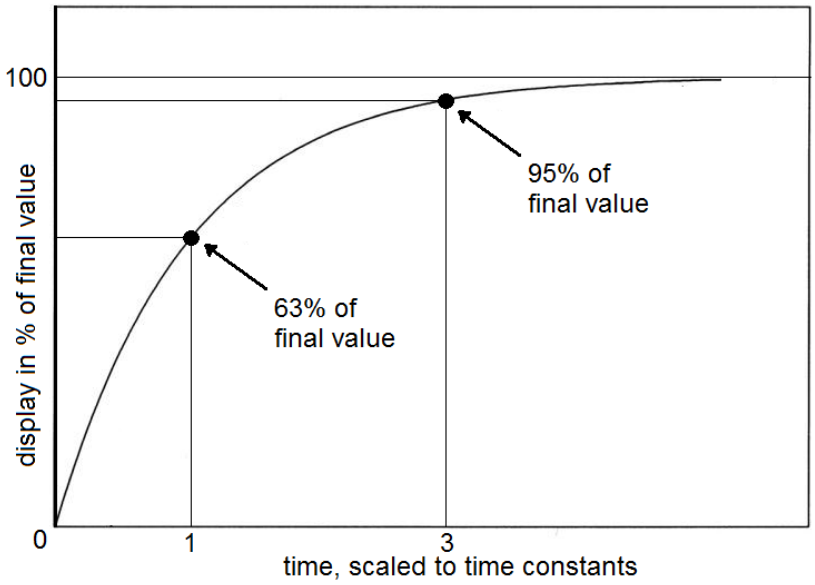


Fig. 1: Rise of the leak rate signal during leak detection

X. **Venting / flushing:** After leak detection measurements, venting of the vacuum chamber or component must be performed by flushing with **dry GN_2** (N_2 quality must be at least 4.5).

XI. **Leak detection of bellows:** If the UHV component to be tested is a bellow or includes bellows, special safety precautions must be undertaken first. During pump-down, the bellows may squeeze abruptly and can cause considerable damage to the vacuum component itself, the vacuum equipment and the personnel conducting the tests. Unless special safety measures have been undertaken, no pump-down of bellows may be started. The UHV component must be fixed in a suitable fixture or jig designed to prevent any axial, angular and lateral deformation of the bellows. Additionally, the pump-down of the UHV component must be done very carefully using an adjustable throttle valve to reduce the effective pumping speed.

3. Leak Rate Measurement

3.1. General Setup

Fig. 2 shows the general setup to be used for leak rate measurements of vacuum chambers and components. The leak detector must be connected directly to the vacuum chamber or component under test and its volume is pumped-down until a stable ultimate pressure is reached. The leak rate measurement must be carried out according to paragraph 3.3. and 3.4, respectively. Large-volume vacuum tanks, however, generally cannot be pumped-down to sufficiently low starting pressures by the integrated pump of the leak detector alone. In this case the leak rate measurement setup must be according to paragraph 3.2.

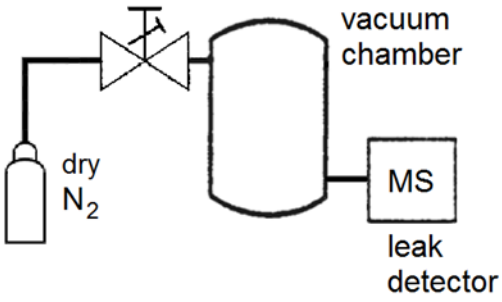


Fig. 2: General leak detection setup

If the object to be tested is a long tube or a tube-like component with very low gas conductance preventing a pump-down to sufficiently low pressures in a reasonable time, the leak rate measurement must be carried out according to F-TG-V-7.39e [1].

3.2. General Setup for Large-Volume Tanks

If large-volume vacuum tanks are to be leak checked, the leak detector cannot be connected directly to the vacuum tank as the pumping speed of the integrated pump of the leak detector is not sufficient. The setup to be used in this case is shown in Fig. 3. A turbomolecular pump (TMP) with sufficiently high pumping speed relating to the vacuum tank under test is connected to a roughing pump via gate valve A. A branch-off to the leak detector is installed via gate valve B between the foreline stage of the TMP and the vacuum tank under test.

For initial roughing and pump-down of the tank, valve A is opened while valve B is closed. Once pressures lower than 10^{-4} mbar are reached in the tank, valve B is opened while valve A is closed. In this way the leak detector assumes the function of the roughing pump of the TMP.

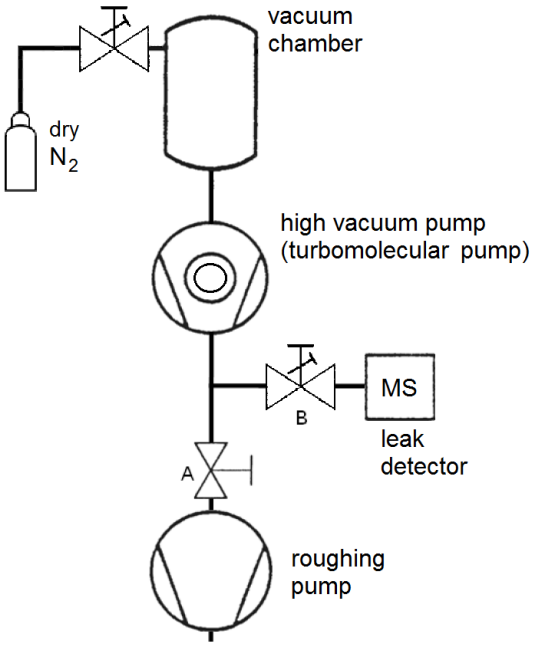


Fig. 3: Leak detection setup for vacuum chambers and tanks with large volumes

For leak detection, He is to be applied to the vacuum chamber, generally by using the integral technique (see paragraph 3.3) or, if necessary, by using the local tracer probe technique (see paragraph 3.4).

3.3. Leak Detection – Integral Technique

The entire vacuum chamber, component or tank must be enveloped by a suitable encasement in order to carry out an integral leak check. Typically, a polyethylene foil sleeve or bag is used, which must be provided by the Contractor. Care must be taken not to cover the connecting flange of the leak detector (otherwise He can permeate through the gasket).

The vacuum chamber or component must be pumped-down to a stable ultimate pressure. For leak checking, He is to be injected into the encasement in such a way that the entire vacuum chamber or component is exposed to a high He concentration. It must be ensured that the polyethylene foil sleeve or bag is gas-tight.

If a leak is detected, further investigation is to be done using the local tracer probe technique (see paragraph 3.4.).

3.4. Leak Detection – Local Tracer Probe Technique

The vacuum chamber or component must be pumped-down to a stable ultimate pressure.

A He tracer probe is to be used to supply He locally to the vacuum chamber or component. All separable joints (e.g. flanges) and inseparable joints (e.g. weld seams) must be examined **systematically, thoroughly and in full length**. During the entire measurement, the He tracer gas must be applied **continuously** (i.e. no intermittent He application is allowed) and as close as possible to the joints using an adequately high He concentration. During the entire leak detection procedure the leak rate reading must remain stable. The response of the leak detector must be consistent with the leak rate signal according to Fig. 1.

4. References

[1] F-TG-V-7.39e Inverse Integral Leak Detection