Metrology for decarbonising the gas grid

# Traceability of portable hydrogen leak detectors

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# Is the European Natural Gas Network ready for hydrogen?

Forthcoming introduction of hydrogen in the European gas network brings many new challenges.

- **Health & safety** requirements are a major concern!


**Hazards of hydrogen**:

- Easy ignition;
- Invisible flame;
- Eagerness to burn or form explosive mixtures with air;
- LEL ≈ 4% in air;
- Easy permeation in many polymers;
- Steel embrittlement.

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# How to measure fugitive leaks and to assure its traceability?

This is one of the key questions addressed by the project “Metrology for decarbonising the gas grid”.

- Which quantity?
- How to trace the quantity to SI units?


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# Which is the best measurand to describe leakage?

**Which quantity to measure leakage?**

## Leak rate (Std $cm^3/s$)

Advantages:

- Describes the true emission rate.

Limitations:

- The risk resulting from the leakage is unknown since LEL depends on the dispersion conditions.
- Is difficult to get if the probe is far from the leak point.

## Concentration (ppm)

Advantages:

- LEL is immediately ascertained.

Limitations:

- True emission rate is unknown.
- Reading depends on uncontrolled dispersion factors.

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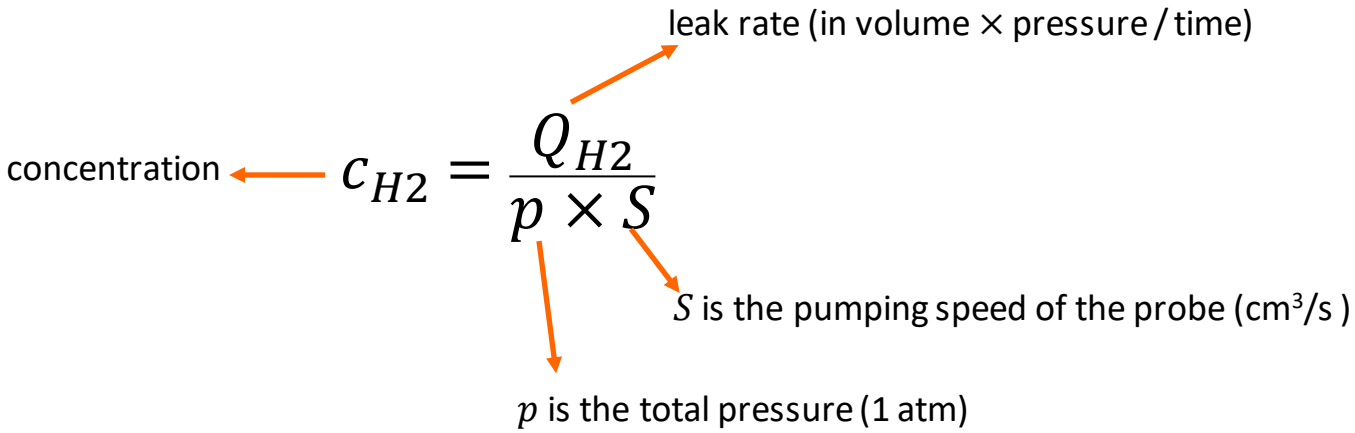
# Relationship between concentration and leak rate?




- For leak rate measurements the instrument needs to 'suck' the whole leakage.
- If the probe has no pumping, only the concentration reading is accurate.

Only few leak detectors are able measure both quantities.

If $S = 1$ cm³/s the concentration reading in **ppm** is the same as the flow rate in Std cm³/s .

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# Measuring range in leak detection

**Since everything leaks what is the smaller H2 leakage of concern?**


**Is the smaller the better?**

Danger:

- Some instruments are able to detect leaks too small.

**OR**

**Is ‘zero’ leakage the goal?**

Danger:

- Any quantity smaller than the measuring resolution is ‘**zero**’!
- Thus, the worst instruments will return zero leakage more easily.


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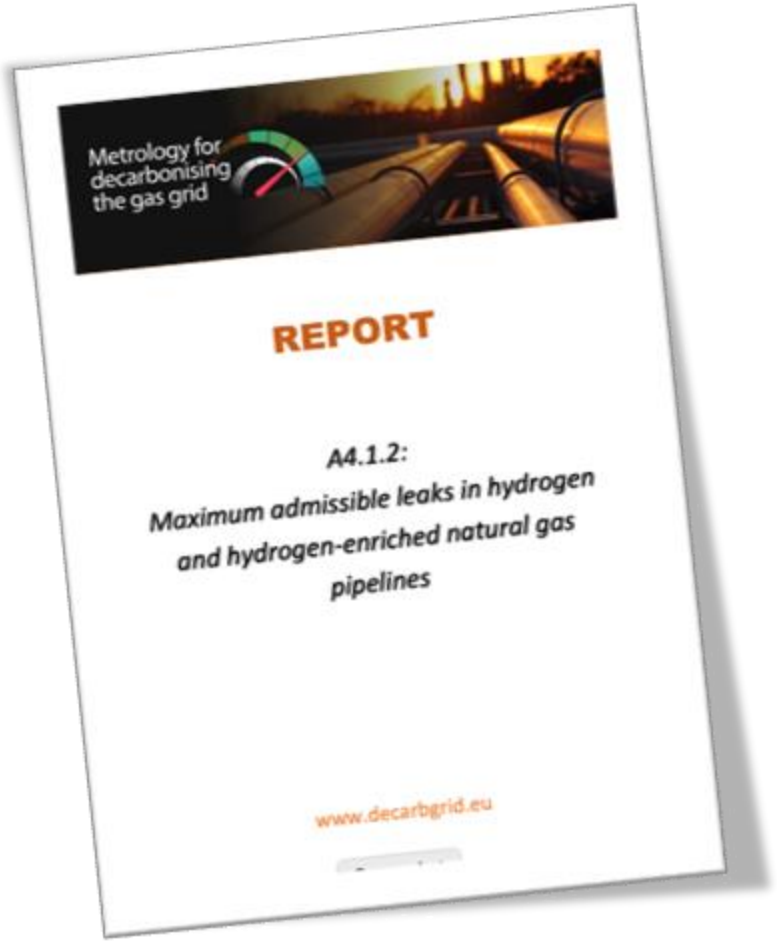
# Maximum admissible leaks!

Is mandatory the definition of **acceptance criteria** to be used in leak testing campaigns.


- This was discussed in a recent review produced in the frame of this project.
- Only data for natural gas was found.
- Criteria depends on the leak detection scenario.

- Gas operators and regulators should discuss / define these quantities for H2.

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# Typical leak testing scenarios

1. **Parts manufacturing**

   Example: gas valves

   ISO 15848 which defines as the tightest requirement a maximum leak of 50 ppm of He (as the tracer gas).

2. **Commissioning**

   Pressure drop tests are often performed. Detection limit is >1 × $10^{-3}$ Std $cm^3/s$ .
   Requirements for high pressure pipelines were not found.

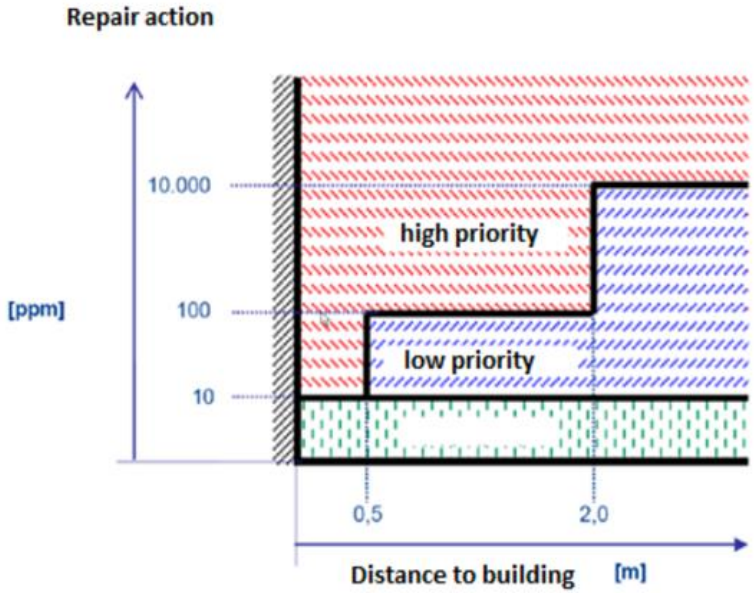
3. **Under operation**

   The tightest criterion found was 10 ppm for **natural gas**

   Since hydrogen brings higher risk, a factor of 10 was proposed leading to

   **1ppm** or **$10^{-6}$** Std $cm^3/s$

This should be **lowest limit required of the metrology infrastructure.**




Dutch standard NEN 7244-6

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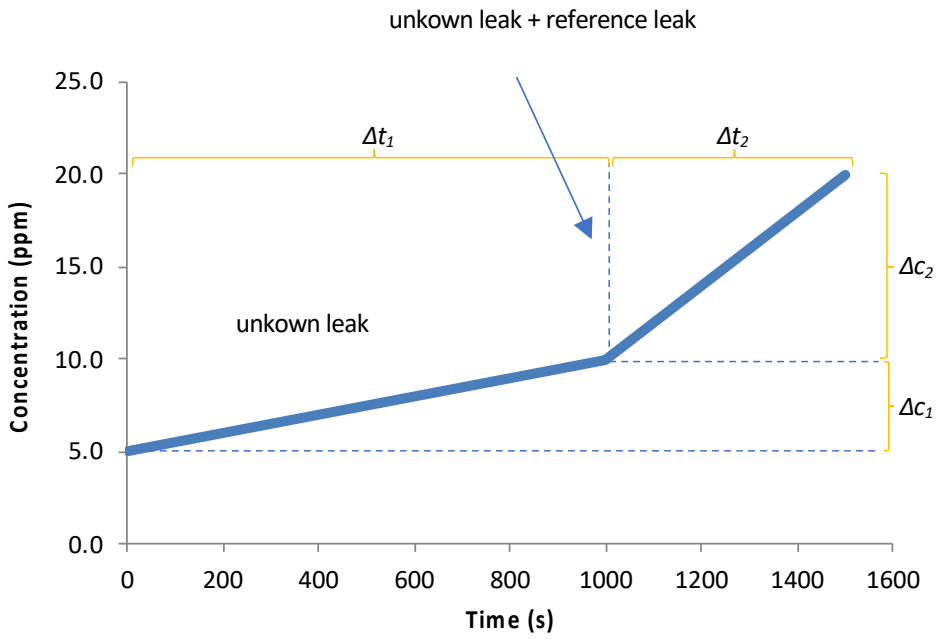
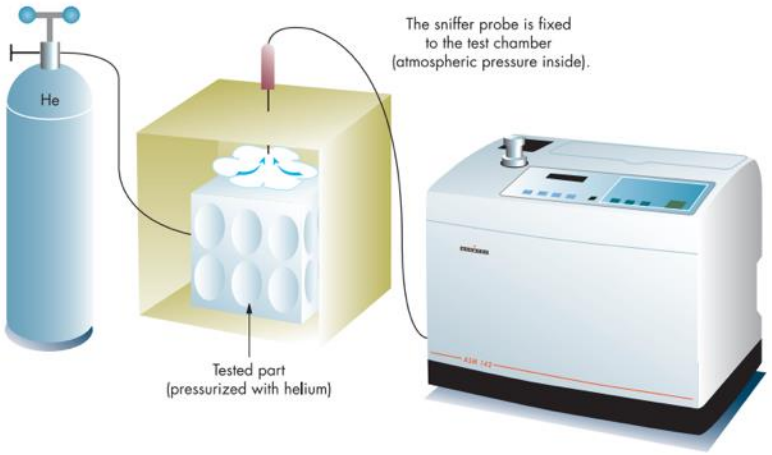
# Getting the leak rate from concentration measurements

- If the leakage can be enclosed by a bag we can calculate the leak rate from the concentration with the support of a **reference leak.**

- **Traceability** is then given by the reference leak**.**




(in the case of quick and homogeneous dispersion)




$$Q_{leak} = Q_{ref}\left(\frac{\Delta t_1 \Delta c_1}{\Delta t_1 \Delta c_2 - \Delta t_2 \Delta c_1}\right)$$

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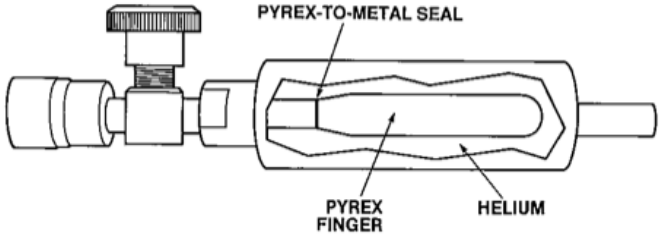
# Reference leaks

In the range $[10^{-6}, 10^{-4}]$ Std cm³/s reference leaks with gas reservoir are often used.

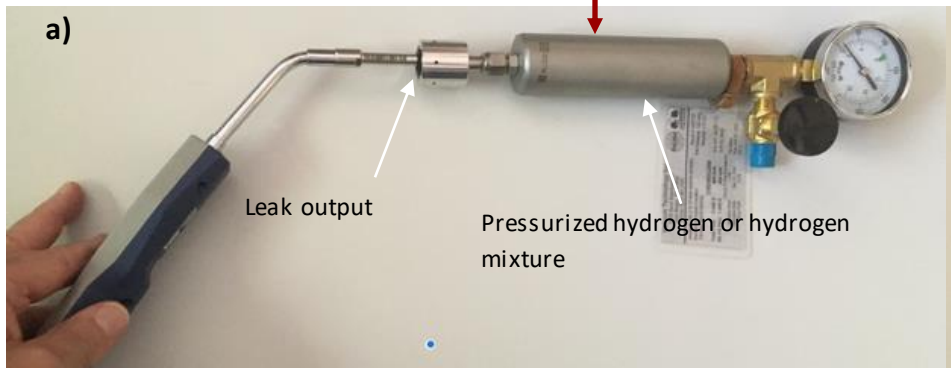
- Depletion rate is low, gas inside the reservoirs last many years.

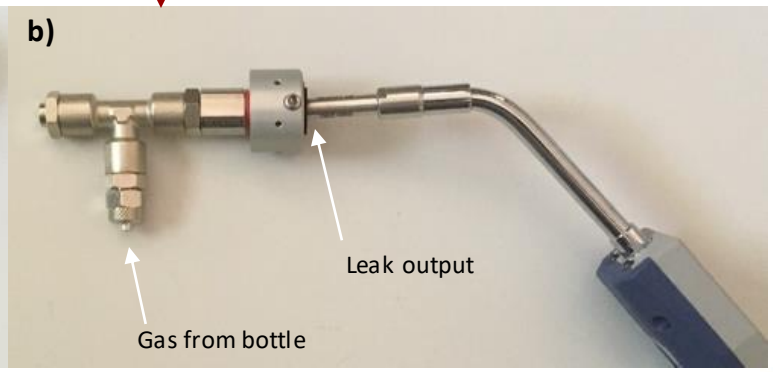



PERMEATION LEAK WITH RESERVOIR AND VALVE

**Reference leaks are small portable artifacts, allowing in situ calibration or sensitivity check of leak detectors**

Reference leaks > $10^{-4}$ Std cm³/s usually require a gas bottle.



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# Should leak detectors be calibrated or just tested?

**Most leak detectors are not measuring instruments.**

- Some are quantitative, others not.

- EU regulations for refrigerant gases just require regular **sensitivity checks** to a leak of 5 g/ year.

- **Traceability is provided by the reference leak used for testing.**


- For many applications, is not relevant the exact value of the leak rate, **just to know if the leak is above the acceptance criterion**.

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# Testing leak detectors

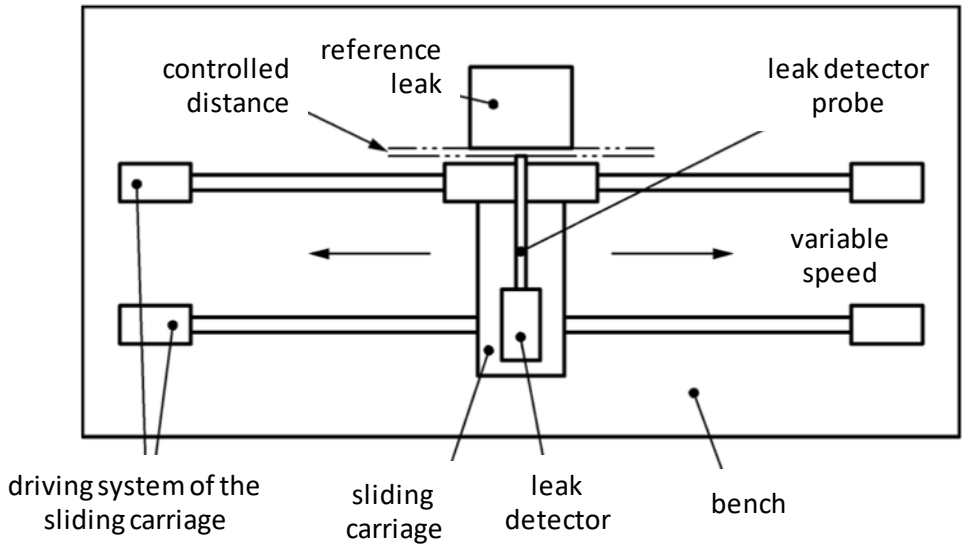
## Static test

- The detector probe is placed as closed as possible to a reference leak.

## Dynamic test

- Probe passes several times in front of the reference leak output.


**EN 14624:2020**

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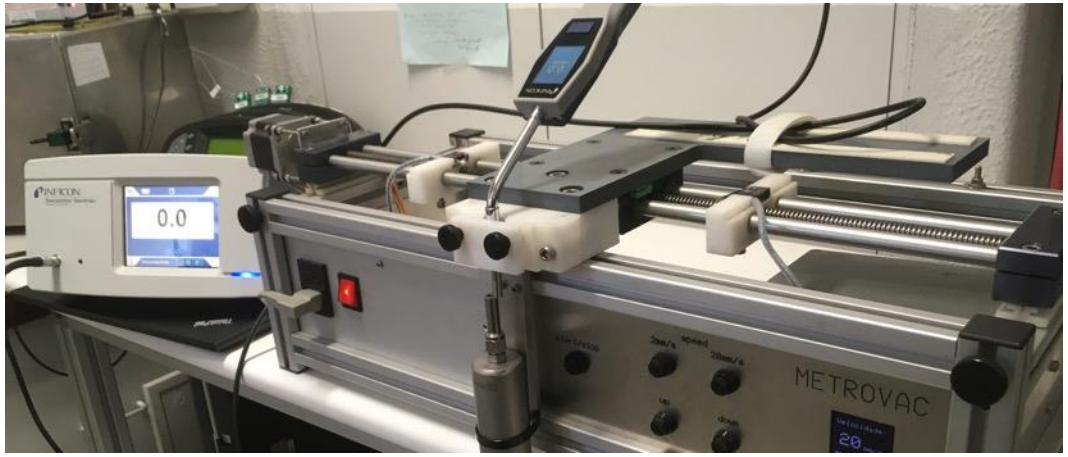
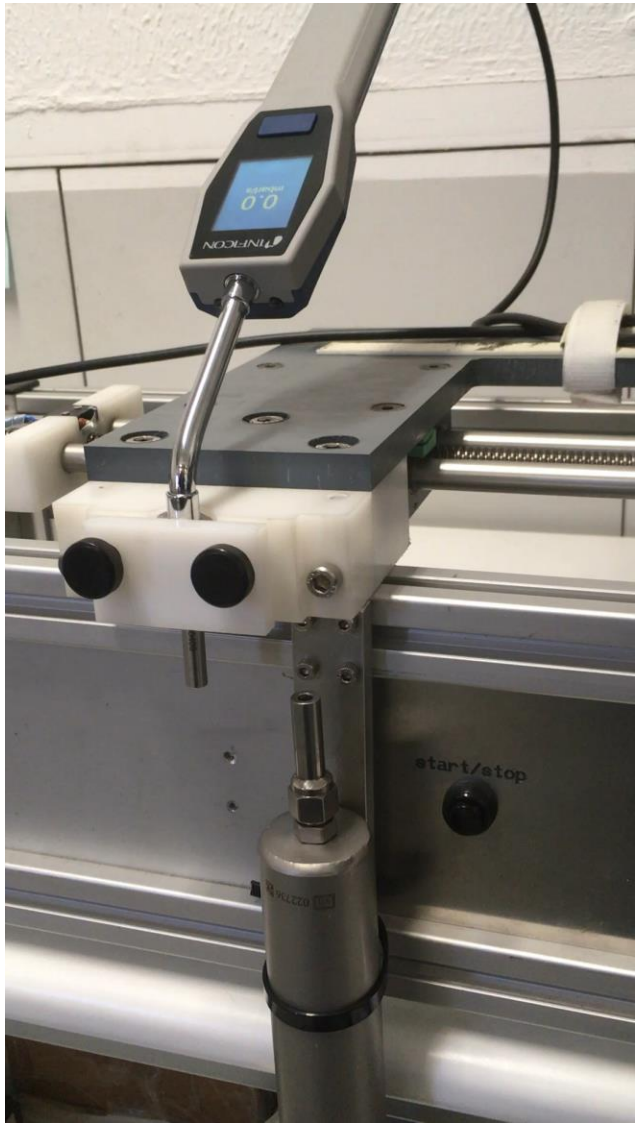
# Bench for dynamic tests

The probe passes by a calibrated reference leak at controlled distance and speed

- Response time, recovery time and repeatability may be assessed.
- Several reference leaks can be used, if needed.

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# Traceability of H2 leak detectors

**The metrology infrastructure should offer calibrations of:**

- Mixtures of $H_2$ in $N_2$ (or in other suitable gas) in the range of 1 to 1000 ppm.
  - 10 ppm of H2 in N2 is available from at least one gas supplier
  - 1 ppm mixture is within the capability of many NMIs

- Hydrogen reference leaks with flow rates in the range $[10^{-6}, 10^{-3}]$ Std cm³/s
  - Only PTB, (CMI ?) and UNL offers calibration in this range for H2
  - LNE is preparing a new calibration set-up

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# Calibration of leak detectors

Calibration of quantitative leak detectors should be performed with a set a references leaks.

- Typically, reference leaks of several orders of magnitude should be used, covering the whole range.
  - MS leak detectors may cover > 6 orders.
- The smallest leak should be close to the detection limit.
- Special attention should be given to the connection of the probe to the leak output.



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# Calibration of reference leaks

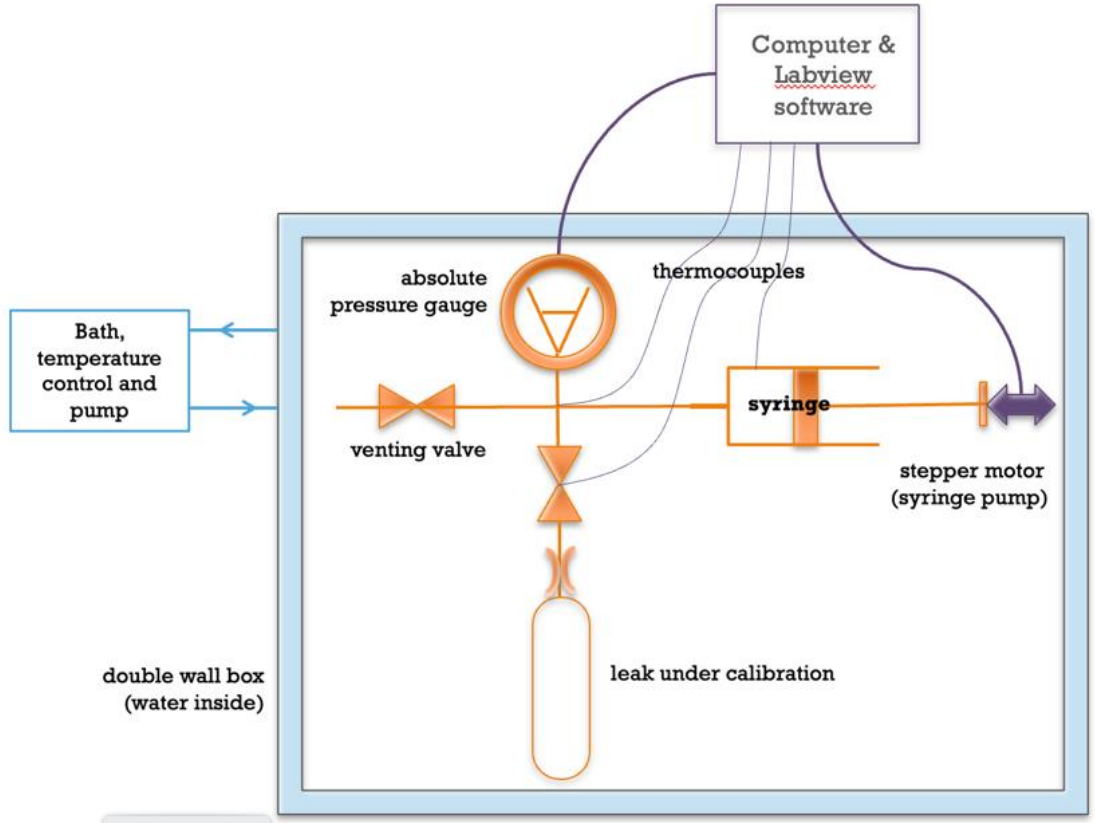
ISO 20486:2017 describes 7 methods for the calibration of reference leaks (also EN13192:2001).

- Method G is suitable for the lowest range.
- The reference leak delivers gas to a closed volume at atmospheric pressure.
- Whenever pressure rise is detected (≈ 1 Pa) the piston expands the volume (≈ 30 nL /step).

Lowest leak rate = $10^{-6}$ Std $cm^3/s$, ( ± 10%).

- (2% @ $10^{-5}$ Std $cm^3/s$)

($10^{-6}$ Std $cm^3/s$ is equivalent to 1 gas bubble in ≈ 40 h)




Constant pressure gas flowmeter at UNL

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# Summary

- Leak rate and concentration are both quantities used in leak detection.
- Quantitative **acceptance criteria** is always required in leak testing.
  - 'Zero leakage' is an incorrect approach.
- Definition of an acceptance criterion (maximum admissible leak) depends on the scenario.
  - Gas operators and regulators should discuss and define these quantities for **hydrogen**.
- Reference leaks are convenient portable devices to test and calibrate leak detectors.
  - Can be produced for any gas
- Reference leaks allow easy traceability of leak testing to SI units.

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# Thanks for your attention

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