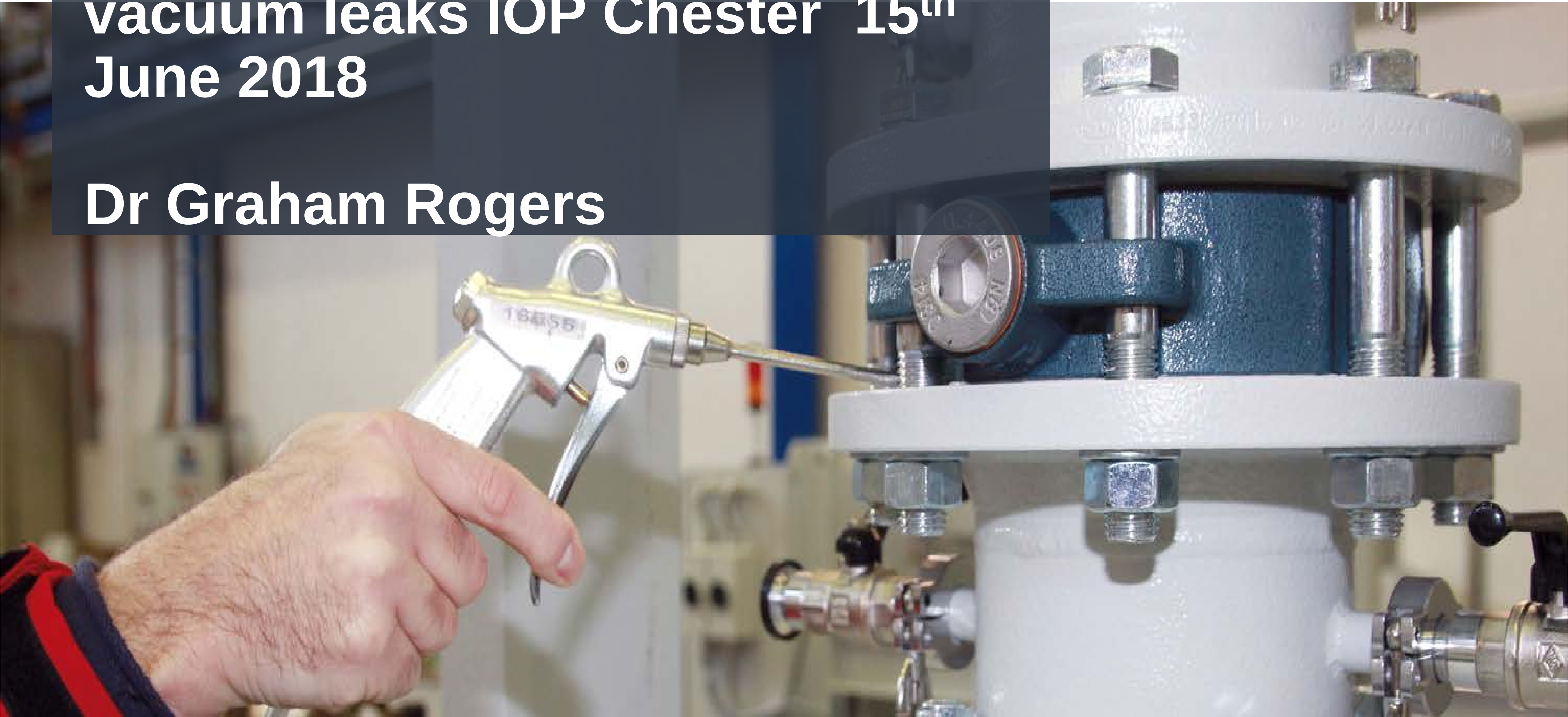
Leybold

Leak Detection and how to fix vacuum leaks IOP Chester 15th June 2018

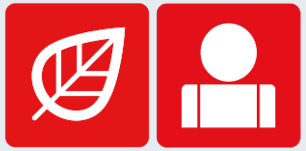
Dr Graham Rogers



AGENDA

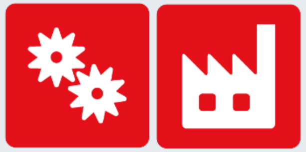
- Purpose and tasks of leak detection
- General terms of vacuum technology
- Definition of leaks and leaks rates
- Method of leak detection
- L300i Helium leak detector
- Calibration and test leaks
- Helium Background
- Partial flow system
- Principle of sniffing leak detection

Reasons for leak detection



Environmental pollution control
Leaks in a pressurized apparatus can cause environmental pollution (toxical liquids or gases)

Protection of products
A product can be influenced by loss of material or intruding strange substances (gas: O_2) i.e., quality and lifetime



Process optimizing
Leaks reduce the efficiency of plants, the process will be disturbed, or the security of the system is endangered

The 4 most important questions

1. Is there a leak ? ⇒ Integral leak detection
2. Where is the leak ? ⇒ Local leak detection
3. How big is the leak ? ⇒ good / bad limit

- General guarantee	(i.e., vacuum components of a manufacturer)
- By law	(i.e., containers for nuclear waste)
- Agreement Manufacturer <> customer	(i.e., acceptance certificate)

4. Corrective action or avoidance possible ?

General terms of vacuum technology

Formular Collection - Summary

Definition	Formular	Unit
$Pressure = \frac{Force}{Area}$	$p = \frac{F_N}{A}$	$\frac{N}{m^2}$; $mbar$
$Gas\ amount = Pressure \cdot Volume$	$= p \cdot V$	$mbar \cdot l$
$Gas\ flow = \frac{Change\ of\ gas\ amount}{by\ time}$	$Q = \frac{\Delta p \cdot V}{\Delta t}$	$\frac{mbar \cdot l}{s}$
$Pumping\ speed = \frac{Gas\ flow}{Intake\ pressure}$	$S = \frac{Q}{p}$	$\frac{l}{s}$; $\frac{m^3}{h}$

General terms of vacuum technology

Conductance

The conductance of an opening in a thin wall or of a line or of a line section between two defined cross sections is the ratio between gas throughput and the difference of the pressures which prevail to both sides of the opening or the line or the line section whereby a temperature equilibrium is assumed in the system (DIN 28 400):

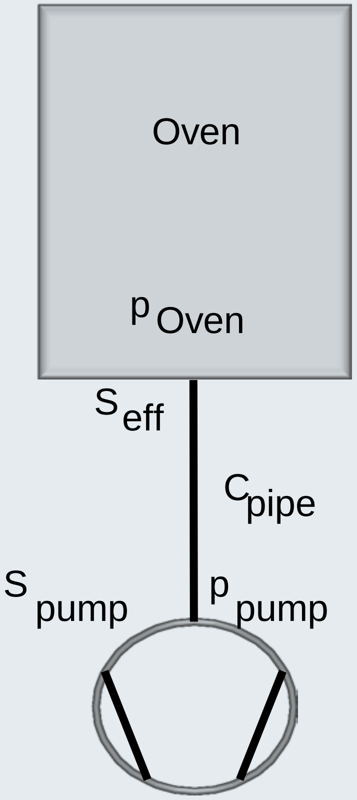
$$C = \frac{\text{Gas throughput}}{\text{Pressure difference}} = \frac{Q}{\Delta p}$$

C = Conductance [l/s]
Q = Gas throughput [mbar·l/s]
Δp = Pressure difference [mbar]

Generally, the conductance is not a constant. The magnitude of the conductance will basically depend within which pressure range the gas flow takes place.

General terms of vacuum technology

Conductance - Effective Pumping Speed



All fixtures between intake of pump system and oven will have the effect of reduction of pumping speed

Equation of continuity

$$p_{oven} \cdot S_{eff} = q_{oven} = q_{pump} = p_{pump} \cdot S_{pump}$$

The effect of reduction of intake piping will be described with conductance C

$$1 / S_{eff} = 1 / S_{pump} + 1 / C_{pipe}$$

Effective pumping speed available at the end of the piping

A piping should always as short as possible with possibly the biggest sensfull diameter

Total conductance of piping:

$$1 / L = 1 / C_1 + 1 / C_2 + 1 / C_3 + 1 / C_n \ (l \cdot s^{-1})$$

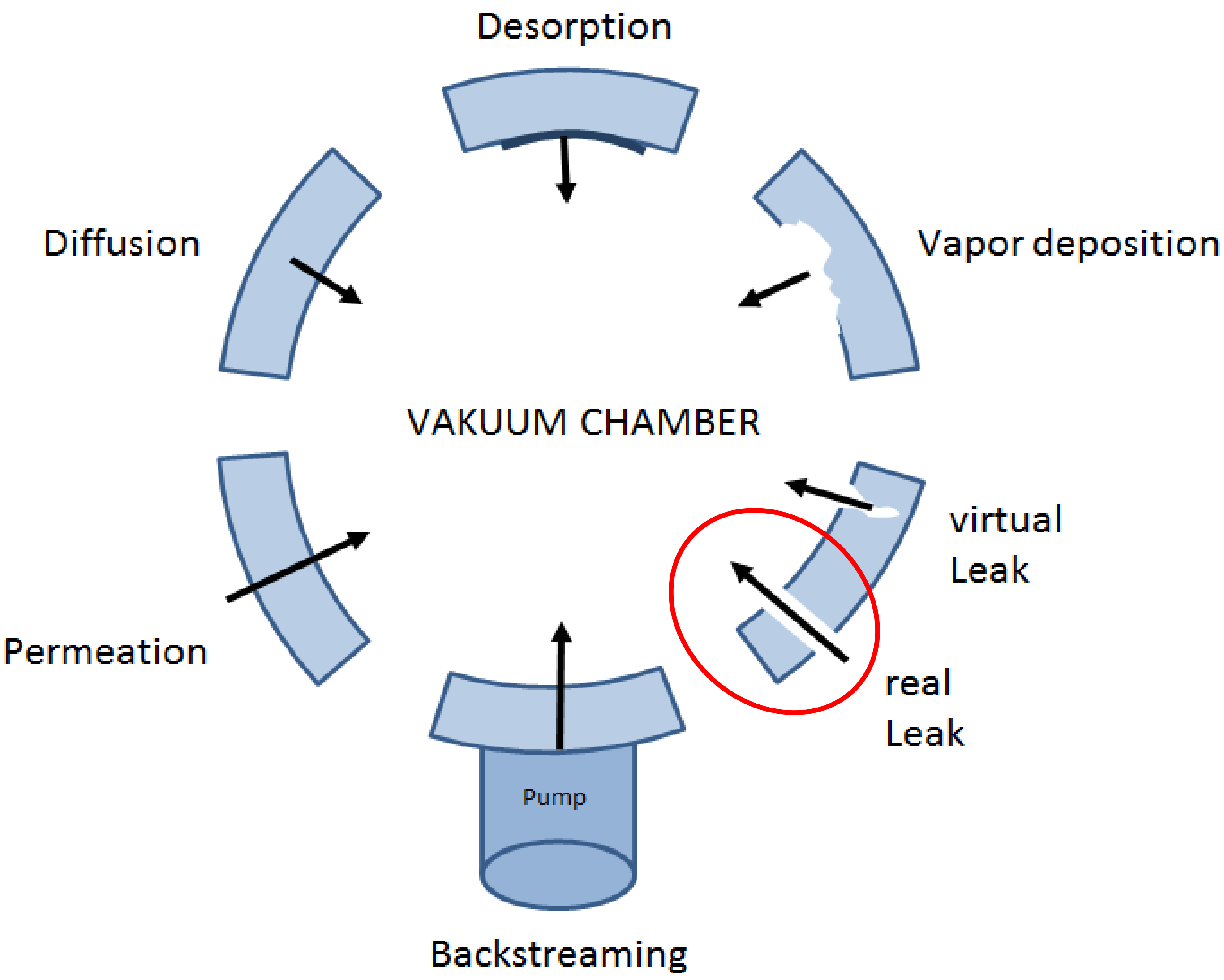
General terms of vacuum technology

Pressure ranges used in vacuum technology and their characteristics

(numbers rounded off to whole power of ten)	**Rough vacuum**		**Medium vacuum**	**High vacuum**	**Ultrahigh vacuum**
Pressure p (mbar)	1013 – 1		1 – 10^{-3}	10^{-3} – 10^{-7}	< 10^{-7}
Particle number density n (cm–3)	10^{19} – 10^{16}		10^{16} – 10^{13}	10^{13} – 10^{9}	< 10^{9}
Mean free path λ (cm)	< 0,01		0,01 – 10	10 – 100000	> 100000
Possible Velocity	Maximum the velocity of sound maximum for vacuum 100 m/s			Maximum thermal velocity, gas type depending	
Impingement rate ZA (cm–2·s–1)	10^{23} – 10^{20}		10^{20} – 10^{17}	10^{17} – 10^{13}	< 10^{13}
Vol.- related collision rate ZV (cm–3 · s–1)	10^{29} – 10^{23}		10^{23} – 10^{17}	10^{17} – 10^{09}	< 10^{09}
Monolayer time t (s)	< 10^{-5}		10^{-5} – 10^{-2}	10^{-2} – 100	> 100
Type of gas flow Knudsen number K = λ / d	Viscous flow K < 0,01		Knudsen flow K = 1	Molecular flow K > 100	
Reynolds number Re	Turbulent Re > 4000	Laminar Re < 2300			
Other special features	Convection depend on pressure		Thermal conductivity depend on pressure	Volume collision rate is strong reduced	Particles on surfaces dominate in relation to particles in gaseous space

Definition of leak and leak rate

Gas flows inside a vacuum chamber

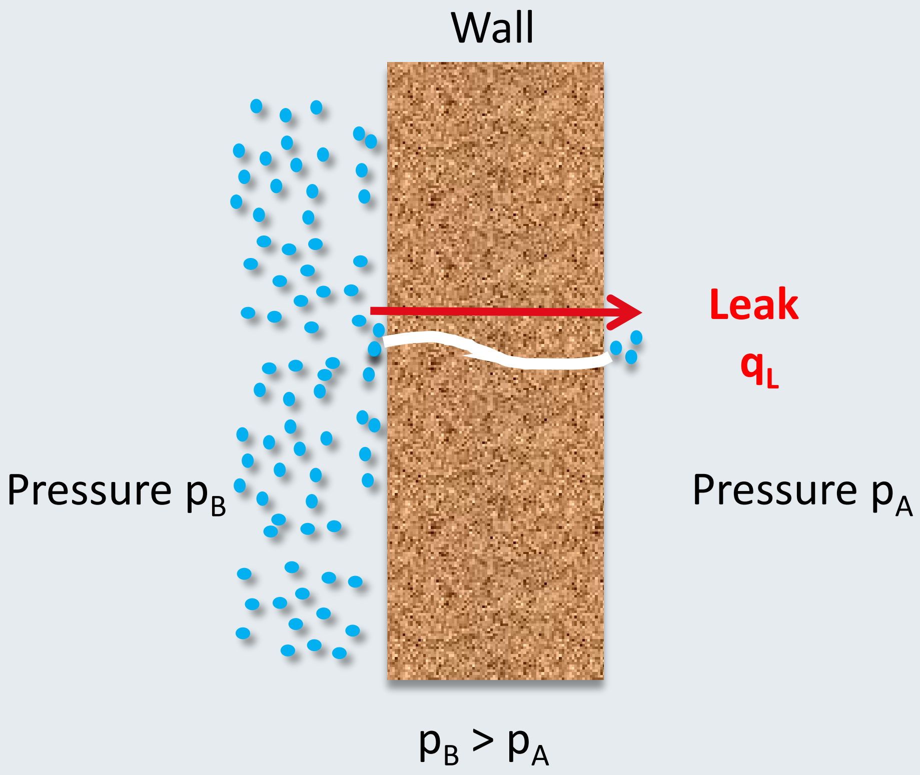


Not every gas flow is caused by a real leak!

Definition of leak and leak rate

What is a leak ?

A leak is an hole in a wall or barrier, through which solids, liquids or gases can enter or exit undesirably in order to compensate an existing pressure difference.



Definition of leak and leak rate

What is a Leak according standards ?

According DIN EN 1330-8 a leak in NDT technology is defined as following:

Hole, porosity, permeable or other structure in the wall of an object capable of passing gas from one side of the wall to the other by the effect of pressure or concentration difference across the wall.

Definition of leak and leak rate

Description of leak rates

For the quantitative description of a leak, the term "leak rate" is used.

Leak rate q_L = Gas-flow which passes through a leak under specific conditions

Pressure rise / drop measurement

$$Leak\ rate\ q_L = \frac{\Delta p \cdot V}{\Delta t} \qquad \frac{mbar \cdot l}{s}$$

Mass loss (T = standard, gas type specified)

$$Leak\ rate\ q_L = \frac{m}{t} \qquad \frac{Gramm}{Year} \qquad \frac{g}{a}$$

Volume loss (p = constant)

$$Leak\ rate\ qL = \frac{V}{t} \qquad \frac{Liter}{Second} \qquad \frac{l}{s}$$

Leakrate as a function of diameter of hole

Calculation:

Pressure difference : Δp = 1013 mbar

Diameter of hole : d = 1 cm

Velocity of gas = Velocity of sound = 330 m s^{-1}

Volume / Second:

330 m/s · d^2 π/4 = 25,92 · 10^3 cm^3 · s^{-1} = 25,92 l/s

Quantity /Second:

1013 mbar · 25,92 l/s = 2,63 · 10^4 ≈ 10^4 mbar l/s

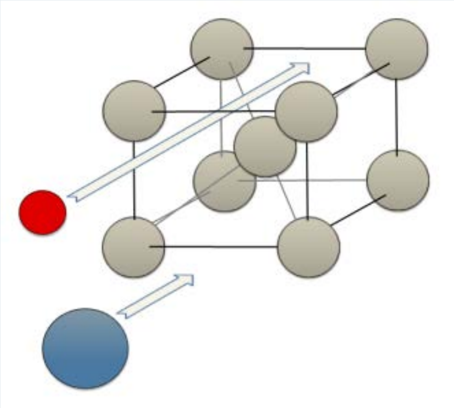
Diameter	Equals Helium leak rate of (mbar l/s)
10^{-2} m = 1.0 cm	10^{4}
10^{-3} m = 1.0 mm	10^{2}
10^{-4} m = 0.1 mm	**10^{0} = 1!**
10^{-5} m = 0.01 mm	10^{-2}
10^{-6} m = 1.0 µm	**10^{-4}**
10^{-7} m = 0.1 µm	10^{-6}
10^{-8} m = 0.01 µm	**10^{-8}**
10^{-9} m = 1.0 nm	10^{-10}
10^{-10} m = 1.0 Angström	10^{-12}

Definition of leak and leak rate

Estimation of leak size

Tight is: If the diameter of the molecule or atom is bigger then the lattice constant of the used material!

Examples for diameter of molecules or atoms	Helium He	$1.90 \cdot 10^{-10}$ m
	Hydrogen H_2	$2.40 \cdot 10^{-10}$ m
	Argon Ar	$2.88 \cdot 10^{-10}$ m
	Nitrogen N_2	$3.15 \cdot 10^{-10}$ m
	Water H_2O	$6.00 \cdot 10^{-10}$ m
	Oxygen O_2	$9.00 \cdot 10^{-10}$ m
Examples for lattice constants	NaCl	$5.60 \cdot 10^{-10}$ m
	Glass	$\approx 5.0 \cdot 10^{-10}$ m
	Aluminium oxide	$5.10 \cdot 10^{-10}$ m



Conclusion

1. Absolute tight is impossible, we have extreme low leak rates only
2. Not each leakage is a leak (faulty place) (Permeation at solid body is seldom, but a special problem of elastomer sealing's)

Definition of leak and leak rate

Standard conditions for to determine Leak rates q_N

1) Gas concentration	C = (100%) 99.9%
2) Pressure difference inside and outside	Δ p = 1013 mbar
3) Temperature	T = 0 °C = 273 K
4) No partial flow leak detection	

Why?

From the common gas equation we know temperature change and pressure change will influence each other and my cause a change of the shown leak rate.

$$p \cdot V = \frac{m}{M} \cdot R \cdot T$$

p	= pressure of gas	[mbar]	
V	= volume	[l]	
m	= Mass of a gas	[g]	
M	= molar Mass of a gas	[g/mol]	
T	= absolute temperature of Gas [K]		T [K] = 273,15 + θ [°C]
R	= molar gas constant	= 83,145 mbar · l · mol-1 · K-1	

Definition of leak and leak rate

Understanding of tightness

Understanding	Leak rate range: For Helium mbar l/s	Leak rate range: For air at 20°C kg/h	Particle size	Remarks
Water tight	10^{-2}	10^{-5}		Drop
Vapor tight	10^{-3}	10^{-6}		Sweat
Bacteria tight	10^{-4}	10^{-7}	D ~ 10^{-6} m	
Fuel and oil tight	10^{-5}	10^{-8}		
Virus tight	10^{-6}	10^{-9}	D ~ 0.3×10^{-6} m	
Gas tight	10^{-7}	10^{-10}		
„Absolute tight"	10^{-10}	10^{-11}		Technical tight (better)

Definition of leak and leak rate

Examples of well known leaks (in Standard He-Leak rate)

Water tap drops 1 per second	$1.7x10^{-1}$	mbar l/s
Hair between O-ring and flange	$1x10^{-3}$ - $5x10^{-2}$	mbar l/s
Bicycle tube in water (bubble test)	$1x10^{-2}$	mbar l/s
Car wheel looses air 1.8 ↘ 1.6 bar in 6 months	$4x10^{-5}$	mbar l/s

Definition of leak and leak rate

Examples for leaks

Depending on the nature of failures occurring, the following types of leak are vary in:

- Leaks in detachable connections:

  Flanges, grindings

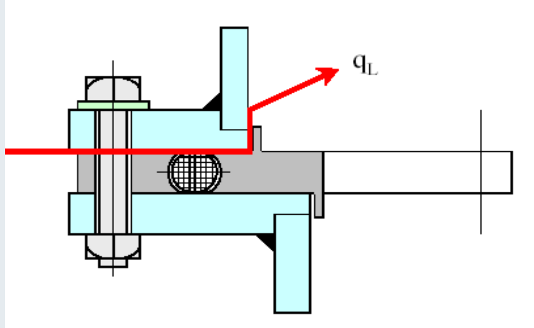
- Leaks in permanent connections:

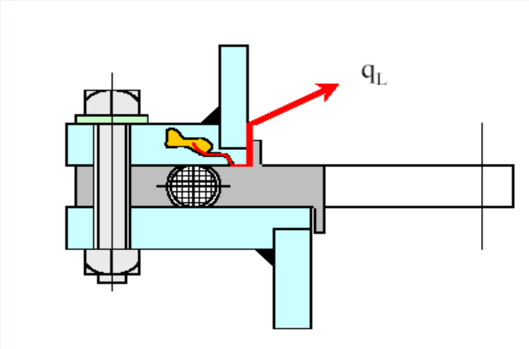
  Soldering and welding seams / spots, glue Joints

- Virtual leaks: In vacuum systems, gases - or evaporating liquids - are released from internal cavities in castings, from gaps and blind holes or from plastics

  Caution:
  - Welding seams should be internal if possible
    (to prevent gaps)

  - Drill screws or slot the screw thread before using screws in blind holes

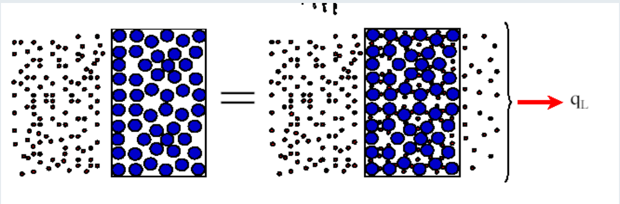


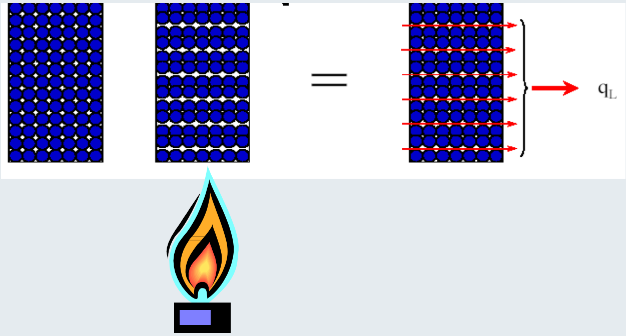


Definition of leak and leak rate

Examples for leaks

- Permeation leaks: If two different gas chambers are separated by a solid wall and with different pressures from each other, gas flows from the gas chamber with the higher pressure through the solid body into the gas chamber with the lower pressure.
- Cold and warm leaks: open after extreme temperature stress, especially at soldering and welding seams / points
- Pore-leaks: typically after mechanical deformation or heat treatment of polycrystalline materials or castings
- In-direct leaks: Untightened feed lines in vacuum systems (water, compressed air, etc.)
- Serial leaks: The leak is at the end of several "series connected rooms".





Methods of leak detection

Comparison

Leak detection-Method	Smallest detectable leak rate: Helium-Standard-Leak rate test gas: Helium 4 Δp = 1000 mbar Q_N	Smallest detectable leak rate: R 134a	Test medium	Method technology	Quantitative leak detection method
	mbar*l/s	g/year			
Helium-Leak detector	**1,0E-12**		**Helium 4**	**vacuum**	**Yes**
Halogen-Leak detector	1,0E-06	0,13	Halogenated substances	Overpressure / vacuum	Yes
Sniff-Leak detector	1,0E-06	0,13	Refrigerant, helium 4 and other gases	Overpressure	Yes
Foaming agent	1,0E-04	0,70	Air & others	Overpressure	No
Thermal conductivity	1,0E-04	0,70	No air but others	Overpressure / vacuum	No
Pressure drop test	1,0E-04	0,70	Air & others	Overpressure	Yes
Pressure rise test	1,0E-04	0,70	Air & others	vacuum	Yes
Bubble Test	1,0E-03	7,00	Air & others	Overpressure	No (yes)
Water-pressure test	1,0E-03	7,00	Water	Overpressure	No

Methods of leak detection

Principle methods of

Pressure change method Group D according DIN EN 1779

Pressure drop test D1

- Integral leak testing (test gas flow out of object)
- test gas: e.g. Air, Nitrogen

Pressure rise test D2

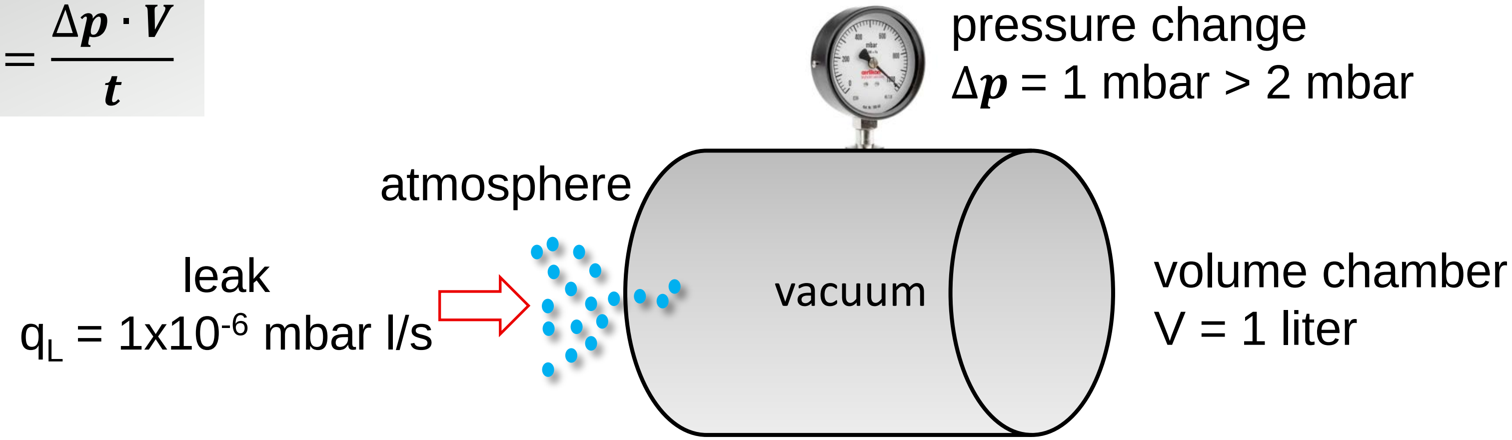
- Integral leak testing (test gas flow into object)
- test gas: Air

Methods of leak detection

Example, the pressure rise method

How long does it take for the pressure in a 1 liter chamber to rise from 1 to 2 mbar when the leak is $1x10^{-6}$ mbar l/s ?

$$q_L = \frac{\Delta p \cdot V}{t}$$

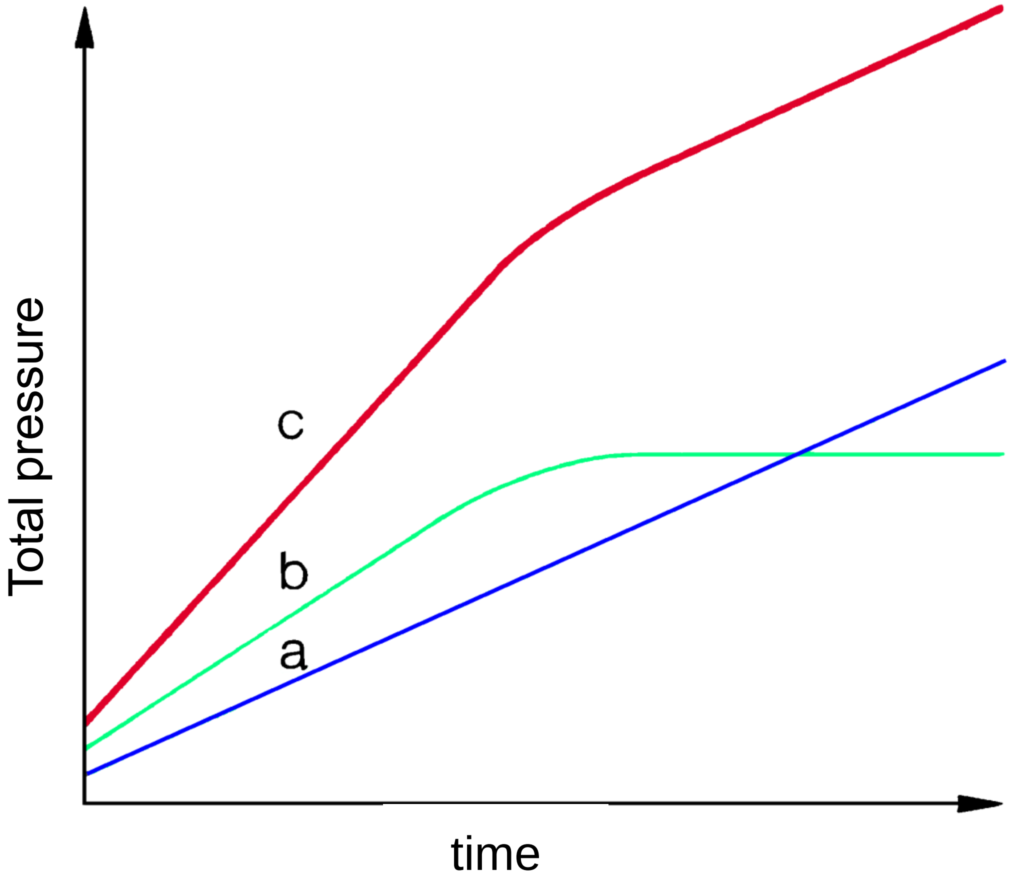


$$t = \frac{\Delta p \cdot V}{q_L}$$

$$t = \frac{1mbar \cdot 1liter}{1 \cdot 10^{-6} mbar\, l\,/s} = 1.000.000s = 277{,}7h = 11{,}5\ days$$

Methods of leak detection

Pressure rise effects on a vacuum tank



a) Leak rate

b) Desorption

c) Leak rate + desorption

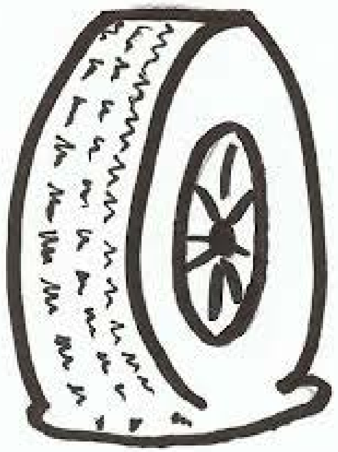
Methods of leak detection

Example, the pressure drop technique (1)

Given data:

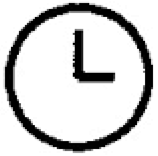
Leak in the tire	q_L	= 1 mbar · l · s^{-1}	
Pressure in the tire	p	= 2 bar	(2000 mbar)
Min operating pressure	p_{min}	= 1,3 bar	(1300 mbar)
tire volume	V	= 20 l	

How long can be driven with the tire until the minimum operating pressure is reached?



$$t = \frac{\Delta p \cdot V}{q_L}$$

$$t = \frac{700\ mbar \cdot 20\ liter}{1\ mbar\ l\ /s} = 14.000\ s = 3,88\ h \approx 4\ hours$$



After about 4 hours, the tire can slip from the rim!

Methods of leak detection

Example, the pressure drop technique (2)

task:

The tyre pressure should be sufficient for at least half a year. (6 months = 1,58 · 10^7 s)

What is the leak rate q?

$$q = \frac{\Delta p \cdot V}{t}$$

$$t = \frac{700\ mbar \cdot 20\ liter}{1,58\ \cdot 10^7 s} = 8,86 \cdot 10^{-4} mbar\ l/s \approx 1 \cdot 10^{-3} mbar\ l/s$$

> the leak is here already factor 1000 smaller!

If the required time is 1 year, the leak rate will be : q_{max} = 4,4 · 10-4 mbar l/s

Detection limit, means smallest visible leak rate in the water bath (bubble test) ~ 1· 10-4 mbar · l /s

Methods of leak detection

Principle methods of tracer gas groups A and B according DIN EN 1779

Tracer gas with Vacuum Technique Group A (Helium from outside)

- Integral leak testing A1 (Helium from outside)
- Local leak detection A3 (Helium spay from outside)
- Tracer gas: Helium

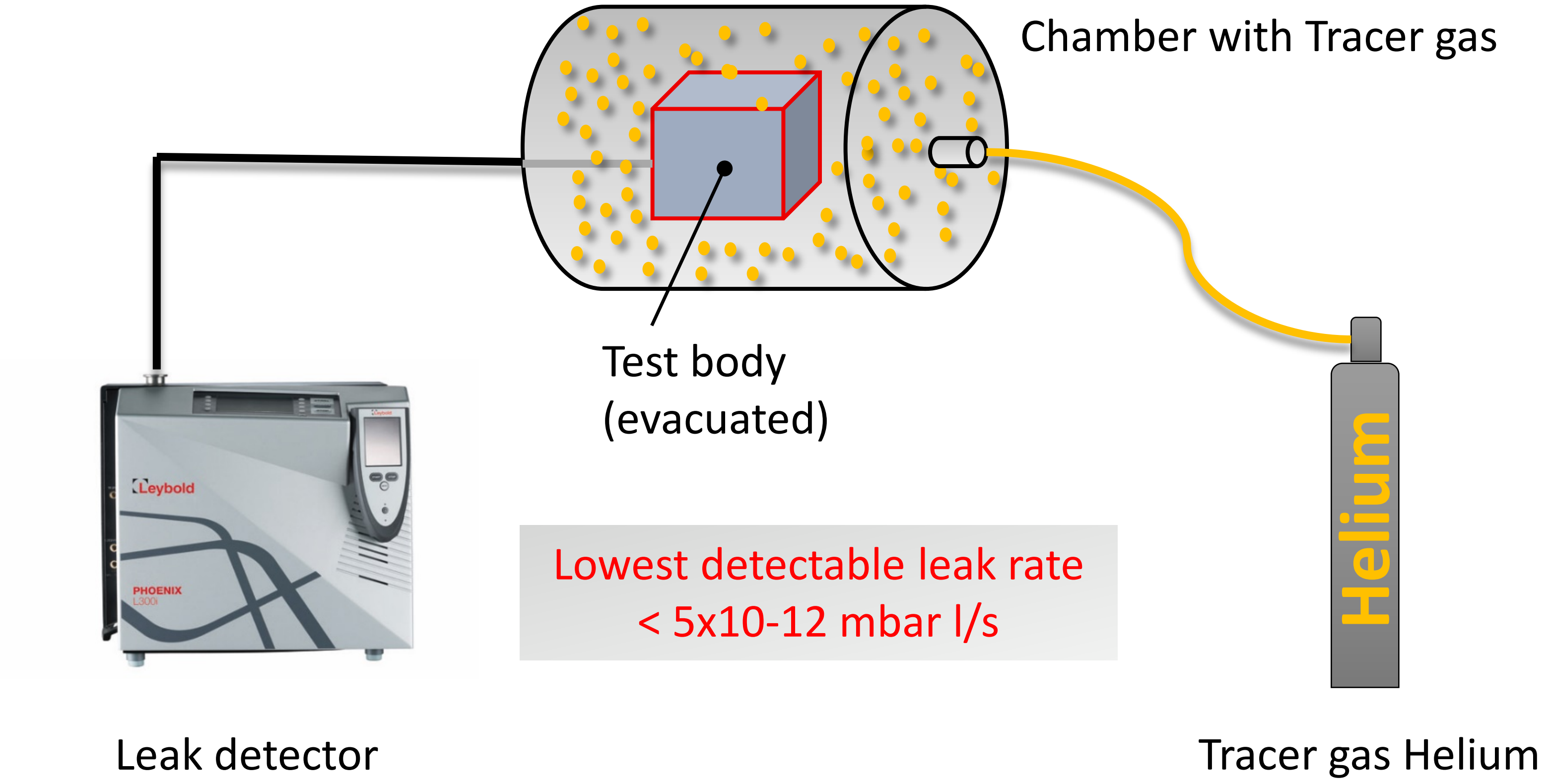
Tracer gas with Overpressure Group B

- Integral leak detection (He inside B6)
- Local leak detection (sniffing B4)
- Tracer gas: e.g. Helium, Halogens, Ammonia

Methods of leak detection

Vacuum Method

Procedure A1 Integral leak detection

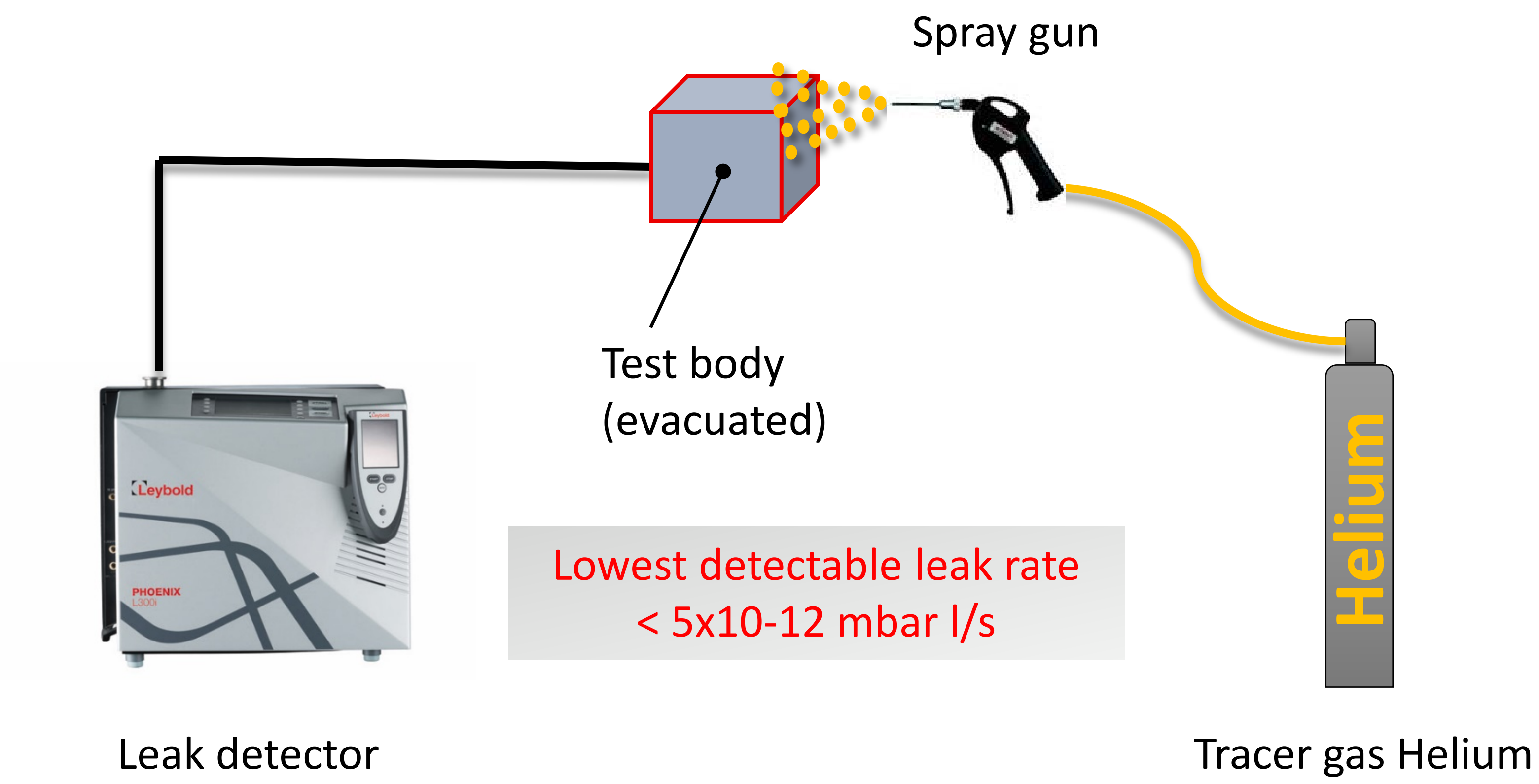


Lowest detectable leak rate
< 5x10-12 mbar l/s

Methods of leak detection

Vacuum Method

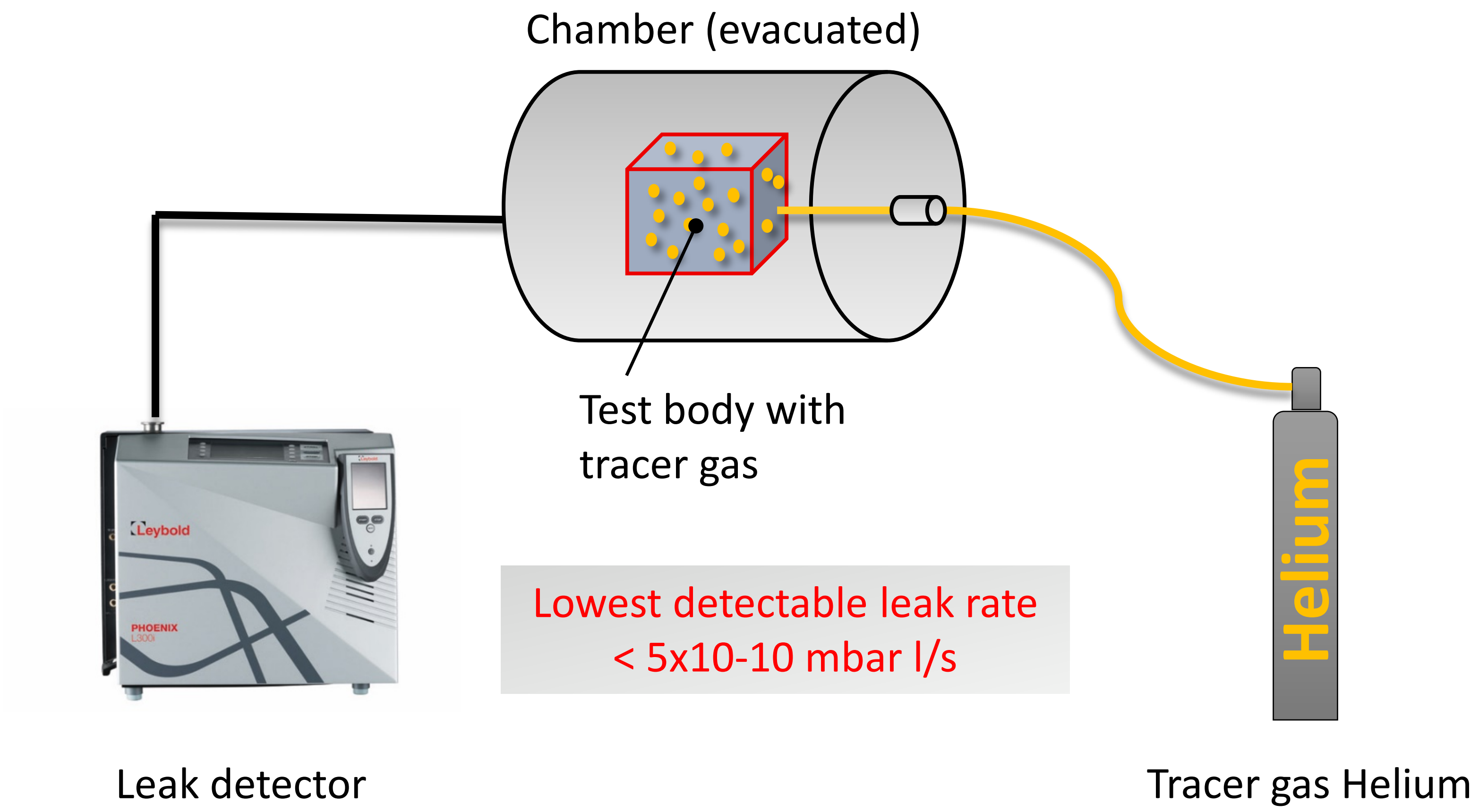
Procedure A3 Local leak detection



Methods of leak detection

Overpressure Method

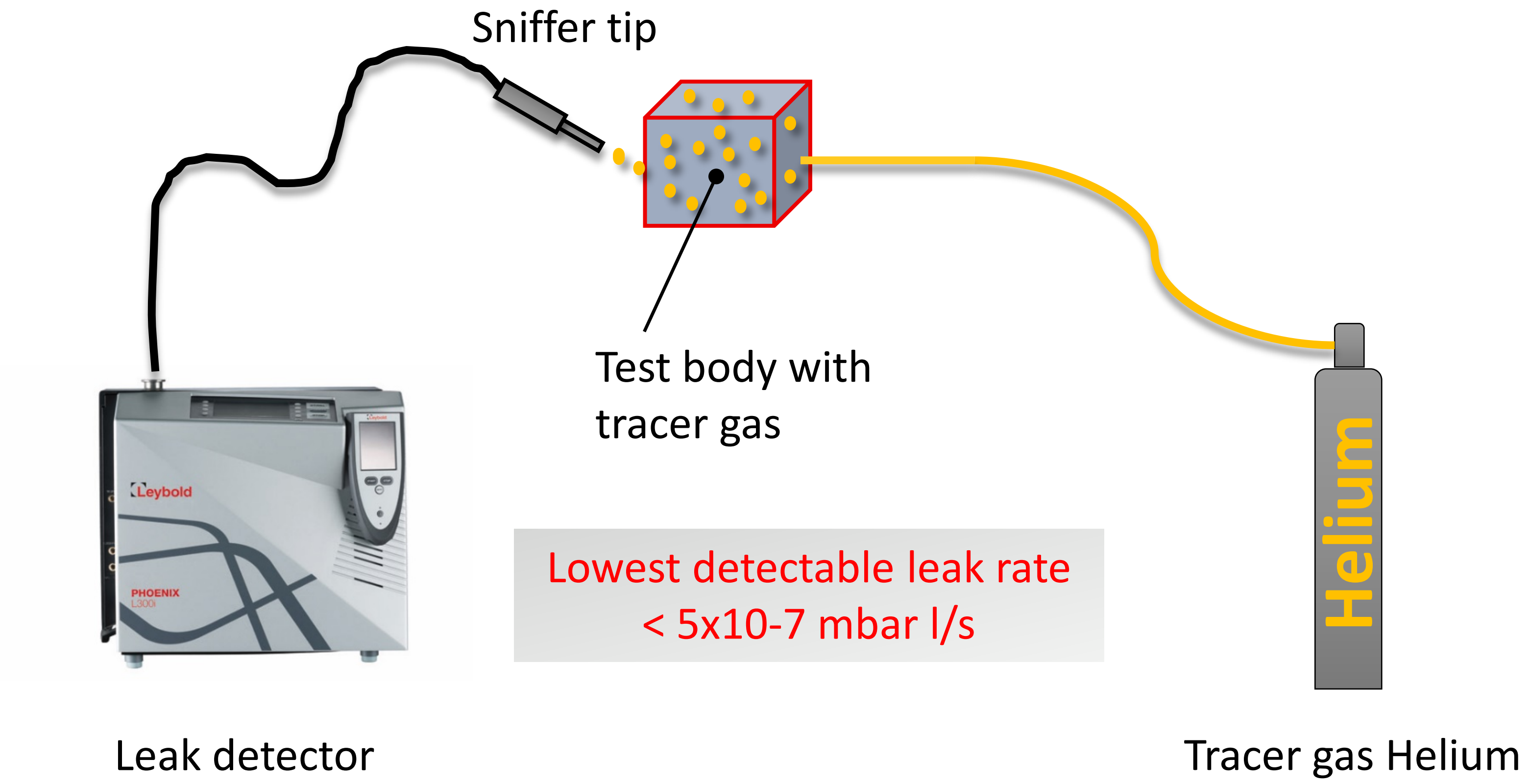
Procedure B6 Integral leak detection



Methods of leak detection

Overpressure Method

Procedure B4 Local leak detection (sniffing)



The Helium Leak Detector

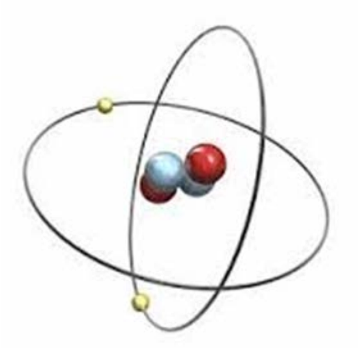
Phoenix L 300 i

The Helium Leak Detector

Helium as Test gas

Gas	Chemisches Symbol	Molare Masse: M	Viskosität bei 25ºC: h (25°C)
		g · mol$_{-1}$	10$_{-6}$ · Pa · s = μ Pa · s
Helium	He	4	19,68

Source: Wikipedia



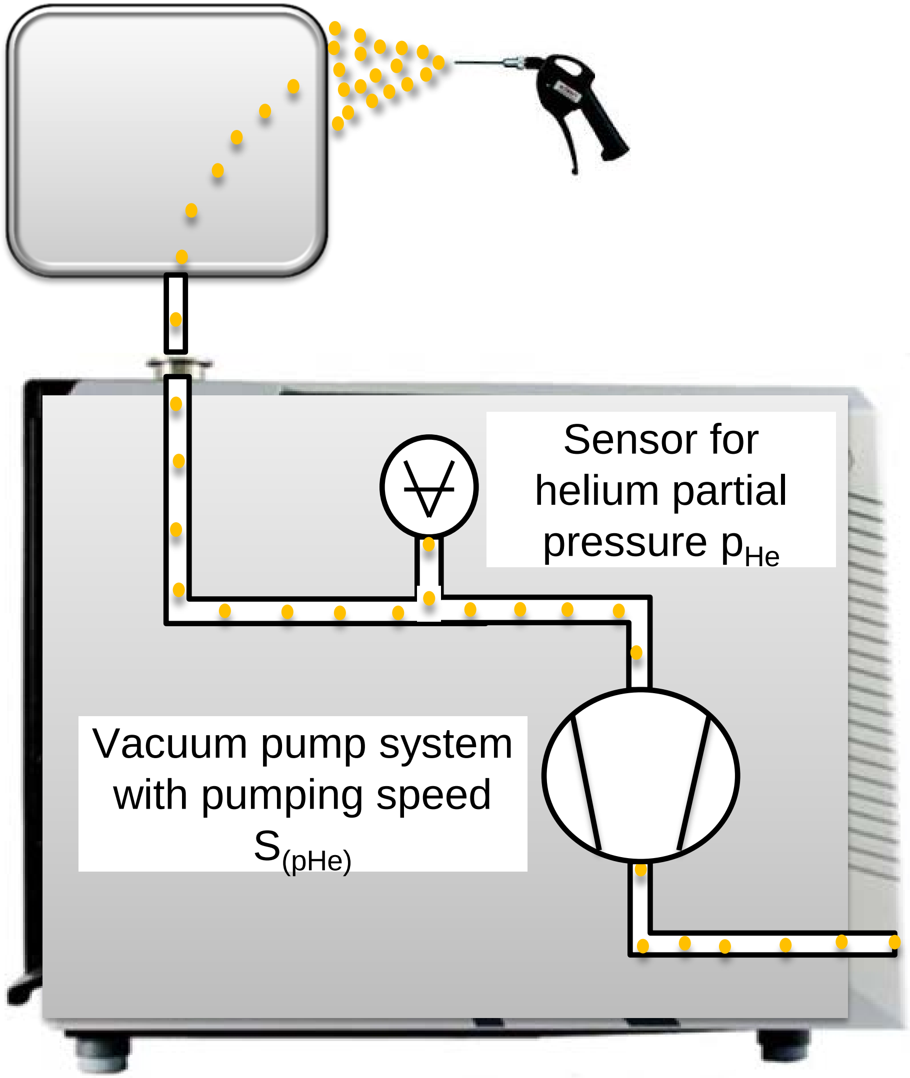
Helium is an ideal test gas for the leak detection.

Its positive features are:

- Excellent separation within a mass spectrometer from neighboring masses
- Only 5 ppm are contained in the air, i.e., a very low background
- Smallest gas particle except hydrogen
- Inert, i.e., does not react with other substances
- Environmentally friendly: non-toxic, non-combustible, non-explosive
- Non-condensable within the entire range of technical applications
- Lighter than air, i.e., it aids leak testing, as the test gas may escape upwards

The Helium Leak Detector

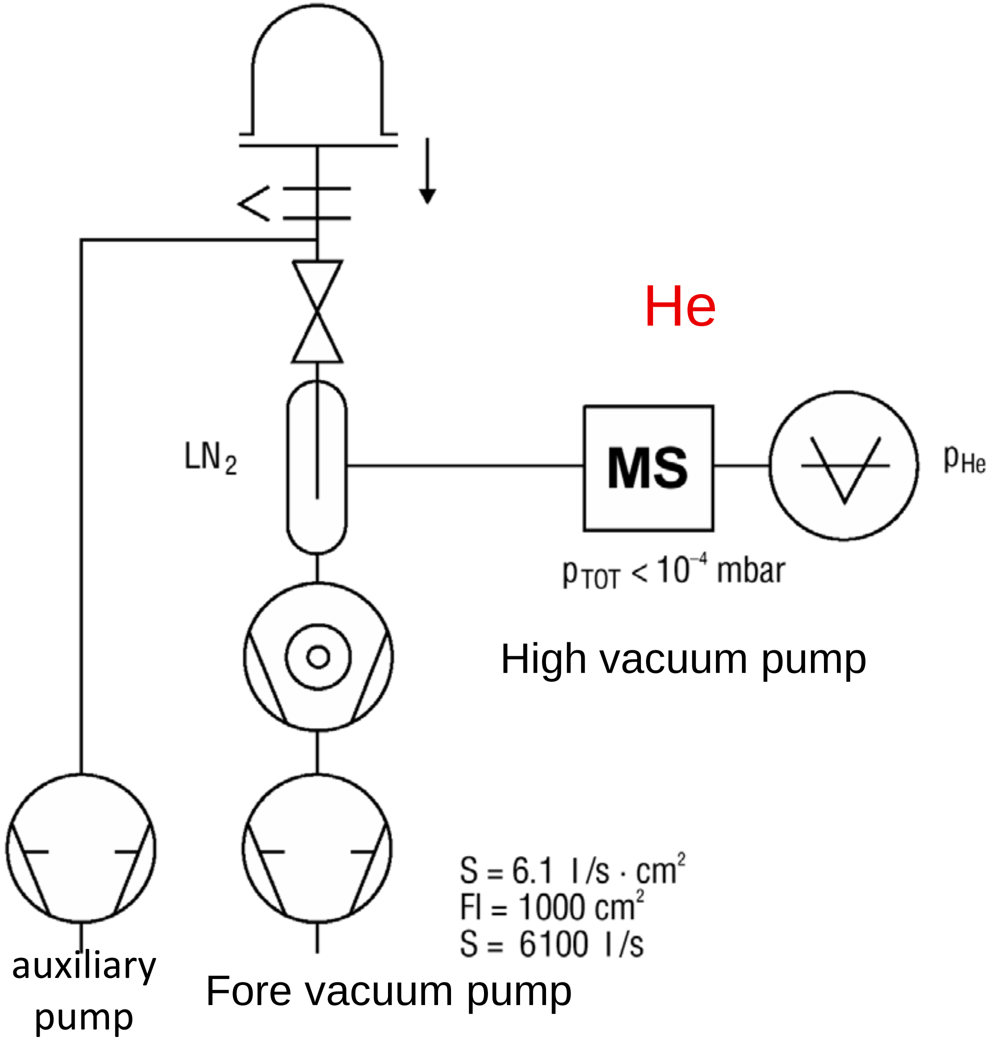
What does a helium leak detector measure?

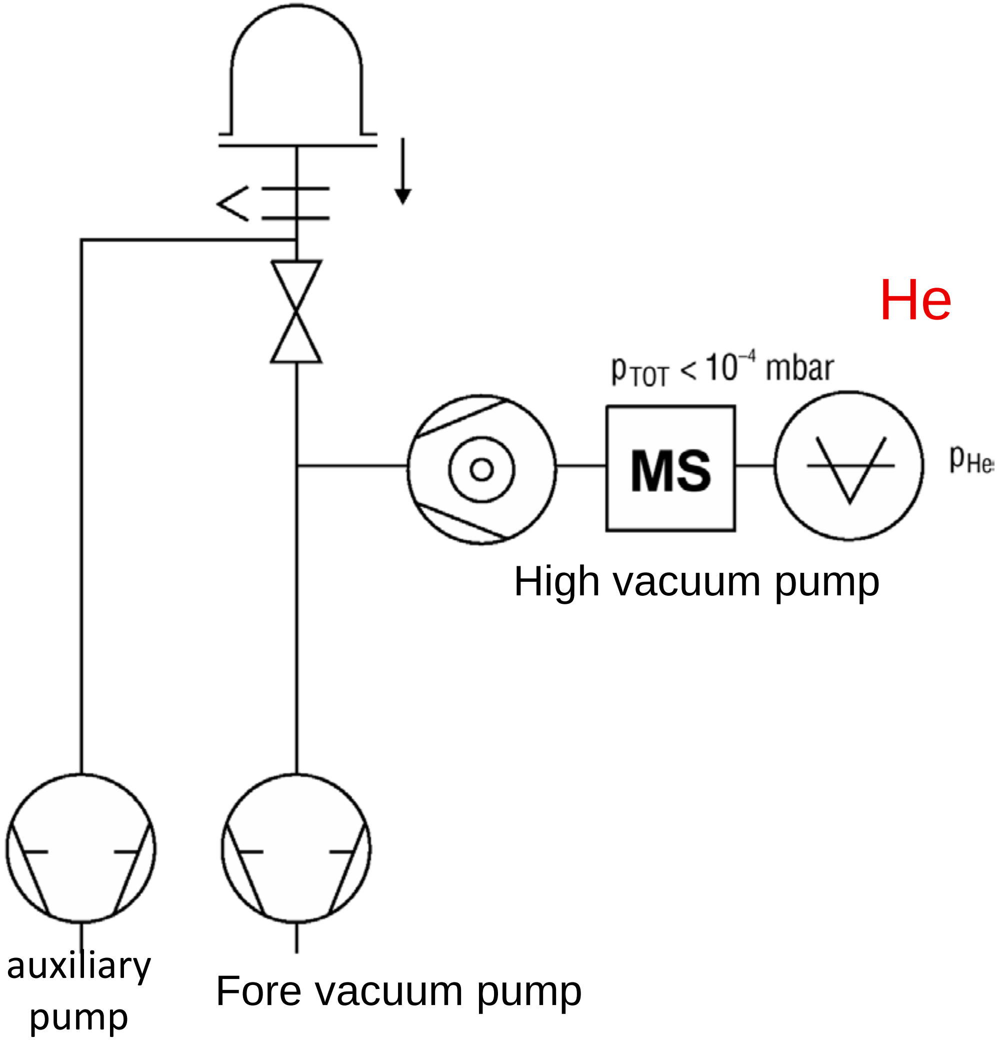


- A Helium leak detector measures the helium partial pressure in the pump line and converts it into a leak rate.

$$q_L = p_{He} \cdot S(p_{He})$$

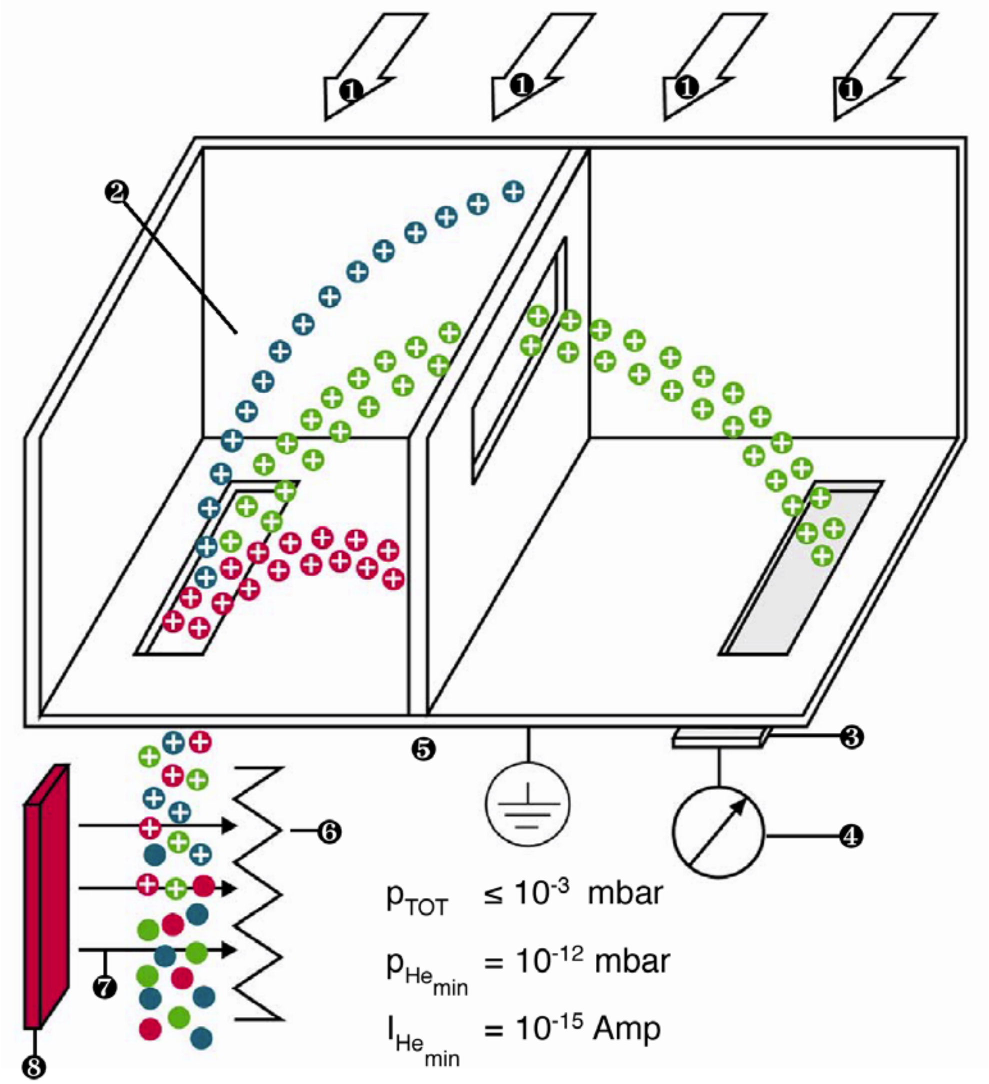
Main flow - and Counter flow – Leak detector





The Helium Leak Detector

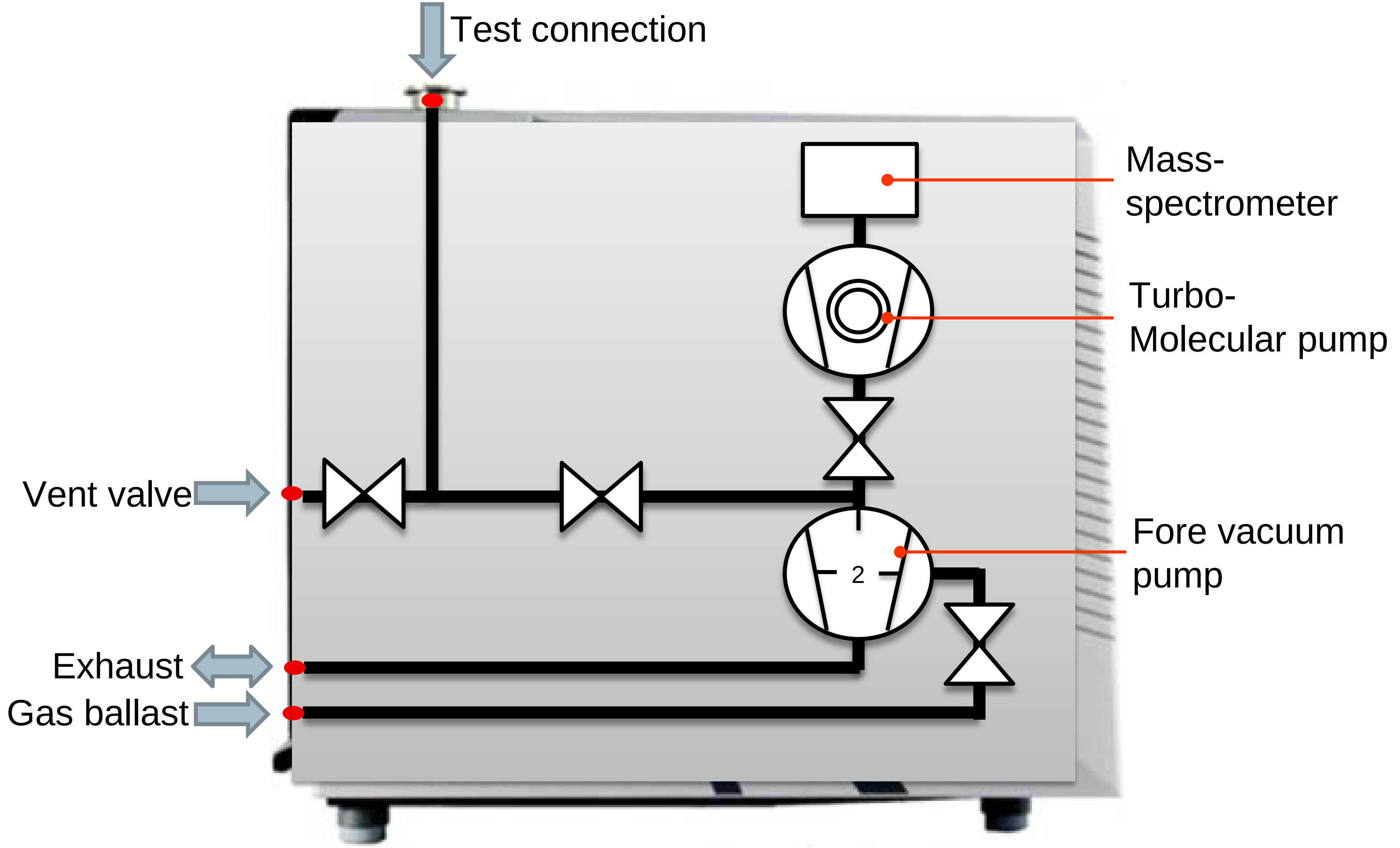
Selective Mass spectrometer, 180° Sector field MS



- ● / ⊕ Hydrogen Atoms / Ions
- ● / ⊕ Helium Atoms / Ions
- ● / ⊕ Heavy Atoms / Ions
- ❶ Magnetic Field (perpendicular to ion path)
- ❷ Positive Ions (all masses)
- ❸ Ion Collector
- ❹ Ampere Meter and Amplifier
- ❺ Accelerating Voltage
- ❻ Anode
- ❼ Electrons
- ❽ Heated Filament (Iridium/Yttrium coated)

The Helium Leak Detector

Vacuum Diagram of a Counter-flow Leak Detector



The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i

PhoeniXL300
electronic-side

LCD Display

CPU

Frequency converter TDS to run the Turbo pump

Power supply

The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i

PhoeniXL300
vacuum side

Ion - detector

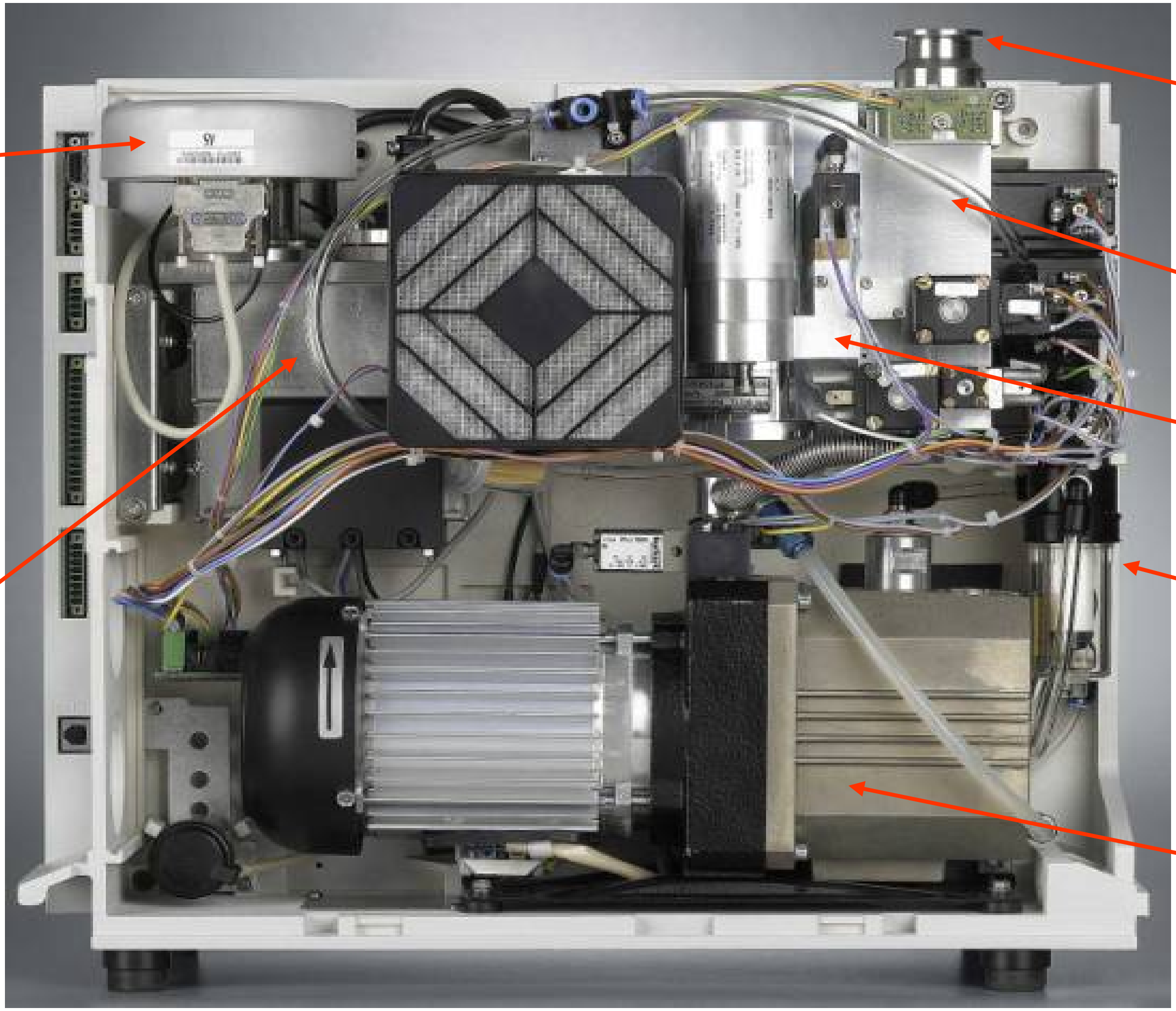
Interfaces:

SPS

Remote

RS 232

180°-Selective Mass Spectrometer



Intake DN 25 KF

Intake-Valve-Block

TURBOVAC
TW 70 LS

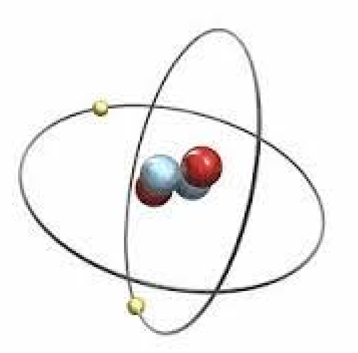
Exhaust-Filter

TRIVAC 2.5 E

The Helium Leak Detector

Getting Started

1. Leak detector warm up



2. Check He-Background, if needed „clean“

3. Calibrate Leak detector

The Helium Leak Detector

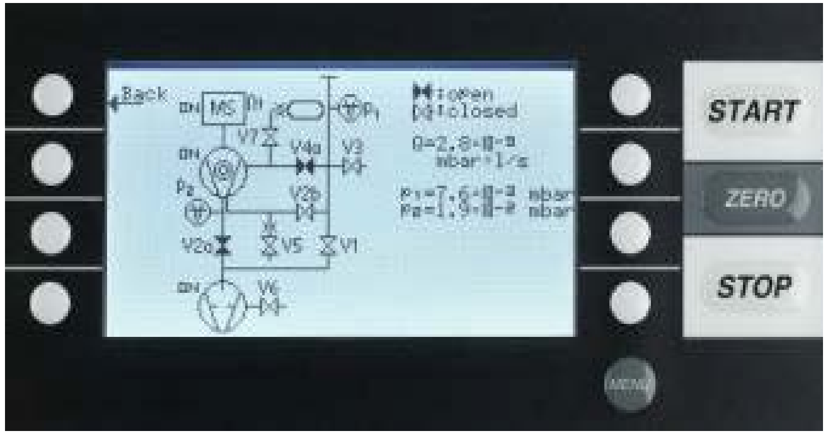
Display Example

Main menu

Trend mode

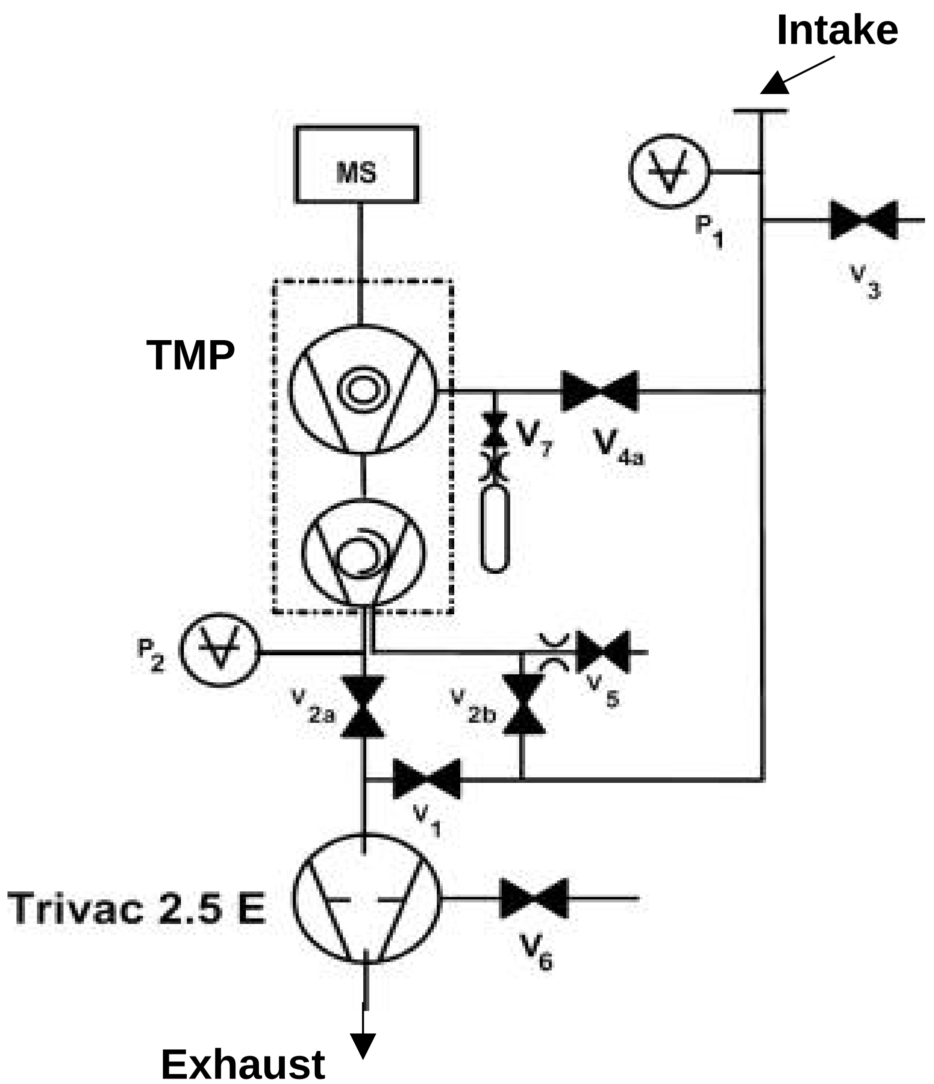
Bar mode

Vacuum Scheme



The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i



MS:	He Mass spectrometer
TMP+Trivac:	Pumps evacuate MS and Test specimen
p_1+p_2:	Control Gauges Inlet and backing pressure
V1	Pump down valve
V2a	Backing valve TMP
V2b	Inlet valve operation Gross mode
V3	Venting valve
V4	Inlet valve operation Fine mode
V5	TMP venting valve
V6	Gas ballast valve
V7	Test leak valve

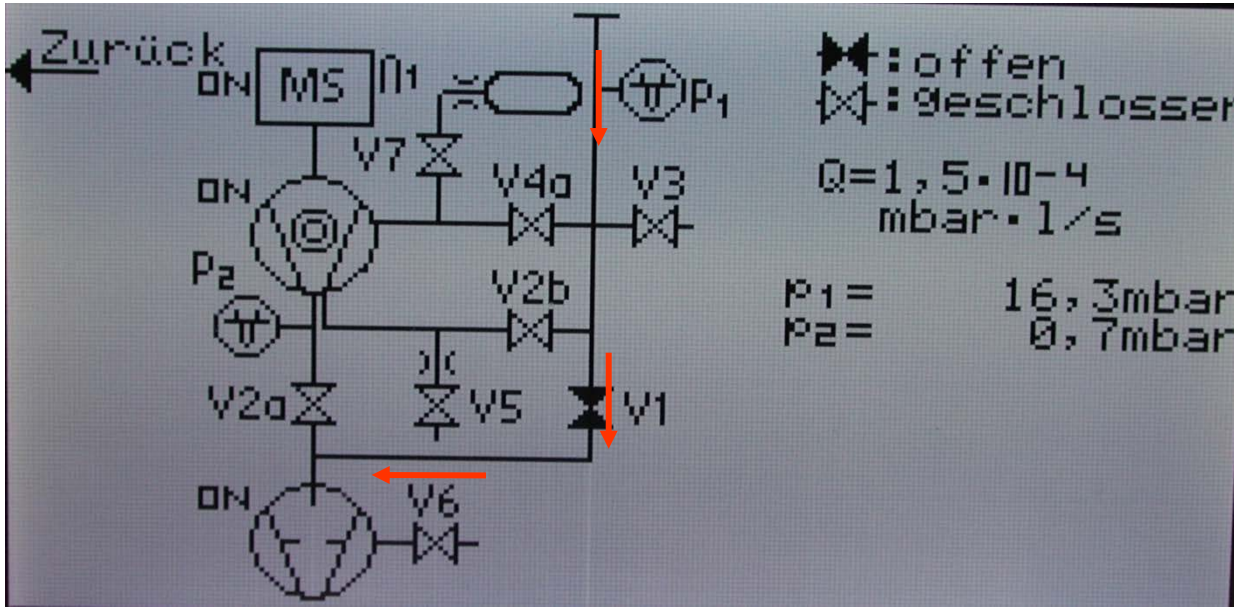
The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i

Measure-Method: **Vacuum(-Technique)**

Measure-Modus: **„No Measure-Modus“**

- Intake pressure: $p_1 >$ 15 mbar
- Start evacuation



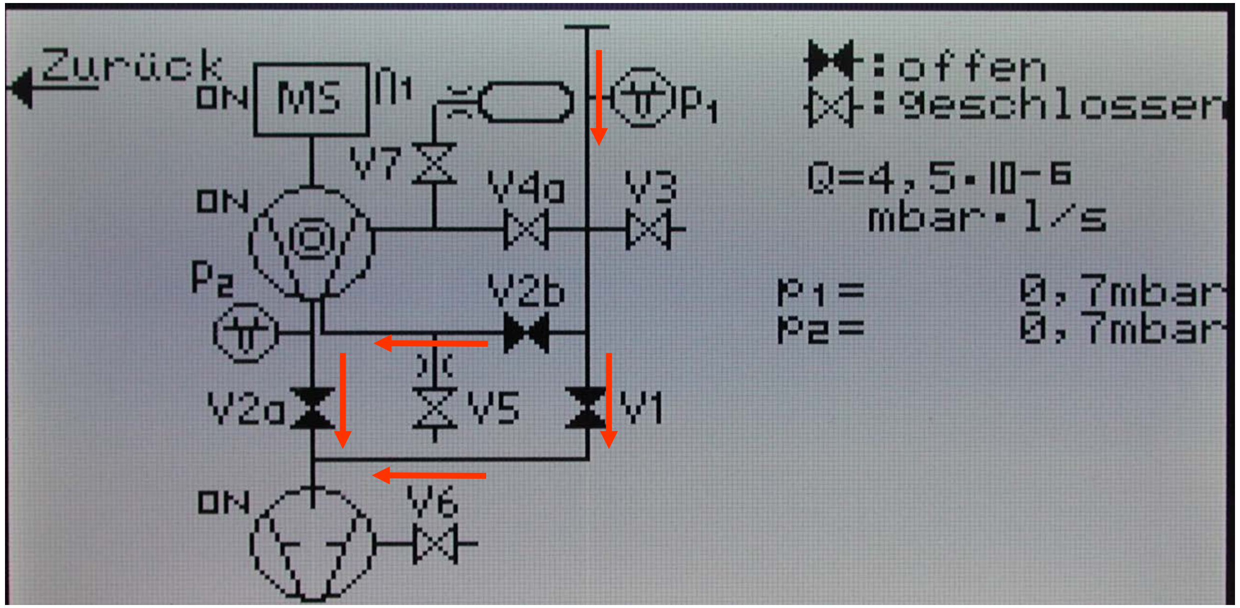
The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i

Measure-Method: **Vacuum(-Technique)**

Measure-Modus: **„GROSS“**

- Intake pressure: 0,1 mbar < p_1 < 15 mbar
- Lowest detectable He^4-Leak rate: $1 \cdot 10^{-8}$ mbar·l/s



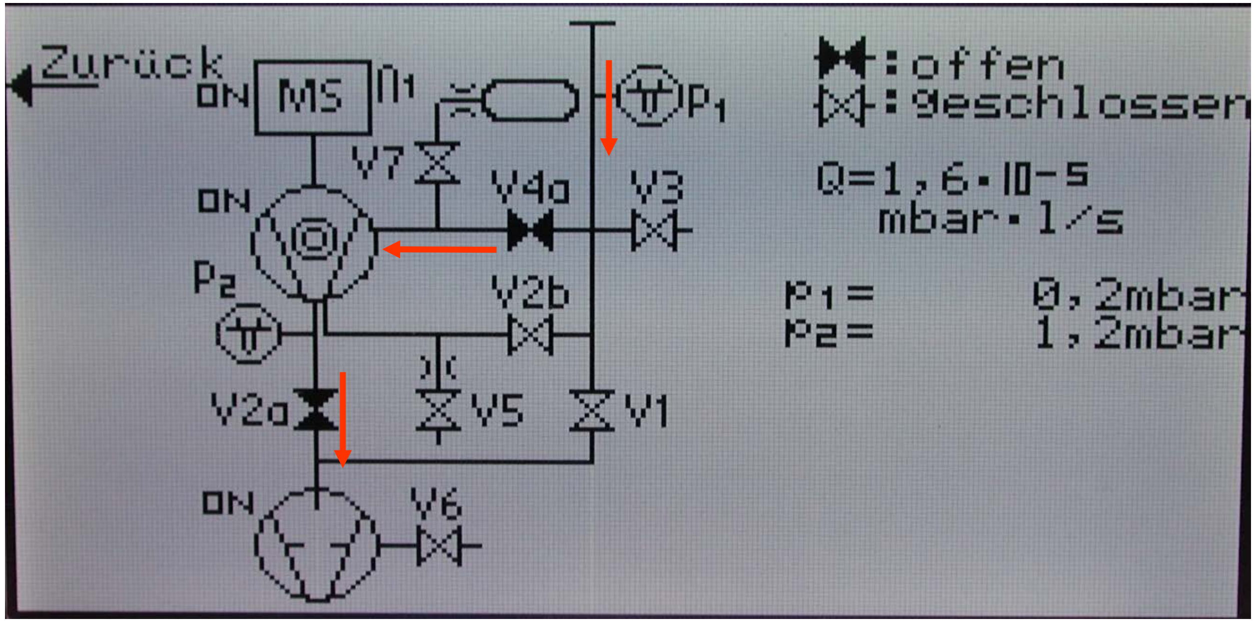
The Helium Leak Detector

Technical design of the He leak detector Phoenix L300i

Measure-Method: Vacuum(-Technique)

Measure-Modus: „FINE“

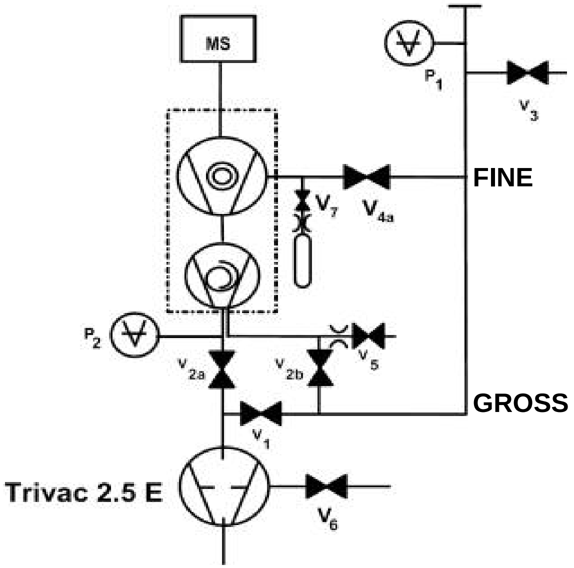
- Intake pressure: $p_1 <$ 0,1 mbar
- Lowest detectable He^4-Leak rate: $1 \cdot 10^{-12}$ mbar·l/s



The Helium Leak Detector

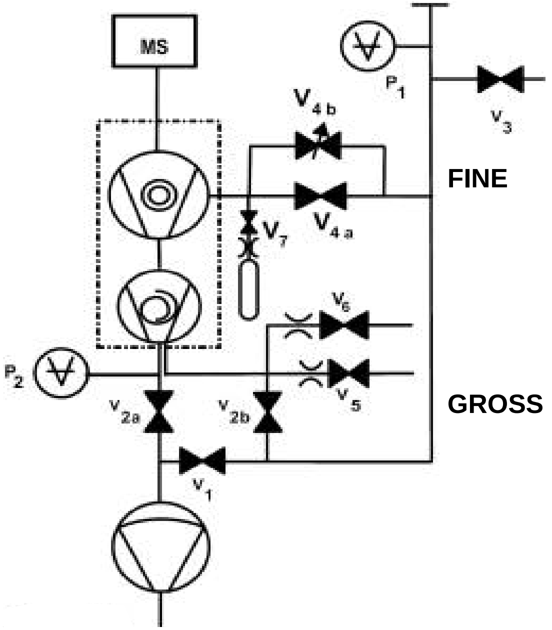
Vacuum schematics of the Phoenix L 300 family

Phoenix L 300 i



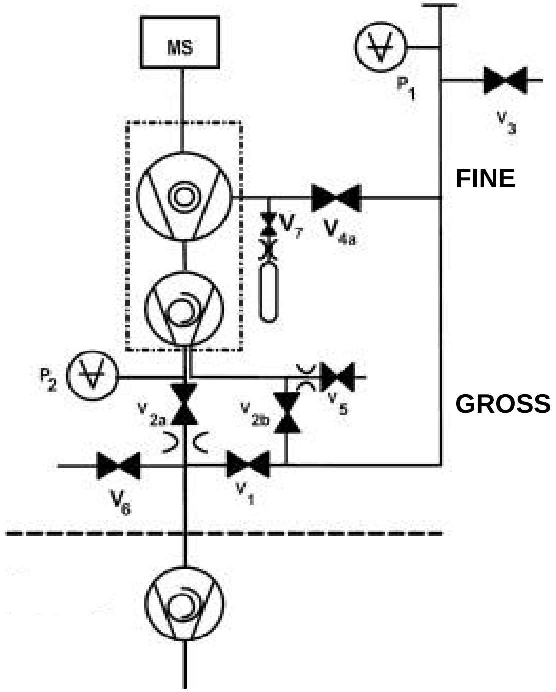
Trivac 2.5 E

Phoenix L 300 i Dry



Diaphragm
Pump

Phoenix L 300 i Modul



External Pump rotary vane
pump or scroll pump

The Helium Leak Detector

Technical Data

		Phoenix L300 i	Phoeniv L300 i Dry	Phoenix L300 i Modul
Lowest detectable He leak rate (vacuum mode)	mbarl/s	$<5x10^{-12}$	$<3x10^{-11}$	$<5x10^{-12}/<8x10^{-12}$
Lowest detectable leak rate (sniffer mode)	mbarl/s	$<1x10^{-7}$	$<1x10^{-7}$	$<1x10^{-8}$
Max. detectable He leak rate (vacuum mode)	mbarl/s	> 0,1	> 0,1	> 0,1
Max. permissible inlet pressure	mbar	15	15	15
Max. permissible inlet pressure w partial flow set	mbar	1000	-	-
Pumping speed during pump down	m^3/h	2,5 (50 Hz) 3 (60 Hz)	1,6 (50 Hz) 1,8 (60 Hz)	16/20 (50/60 Hz) D16B 25/30 (50/60 Hz) D25B 30/36 (50/60 Hz) Scroll
Pumping speed for Helium	l/s	> 2,5	> 2,5	> 2,5
Pumping speed with partial flow set and D16B	l/s	4,4 (50Hz)		
Pumping speed with partial flow set and D25B	l/s	7 (50 Hz)		
Time constant for leak rate signal	S	< 1	< 1	< 1
Time until ready for operation	min	< 2	< 2	< 2
Mass spectrometer		180° magn. Sector field		
Detectable masses ^4He; ^3He; H_2	amu	4; 3 ; 2	4; 3 ; 2	4; 3 ; 2
Power consumption		420 VA	350 VA	350 VA
Weight	kg	40	37,5	29

Calibration - and test leaks

Definition Calibration

Calibration in measurement technology is a measurement process for reliably reproducible detection and documentation of the deviation of a measuring device (here leak detector) from a reference leak (test leak).

The calibration includes a second step, namely the consideration of the deviation during the subsequent use of the measuring device for correcting the readings. The PhoniXL300i automatically performs this correction with the determined "calibration factor".

Calibration - and test leaks

Definition Test Leak

The test leak is a device which emits a precisely known helium gas stream. There are two basic types:

Permeation test leak:

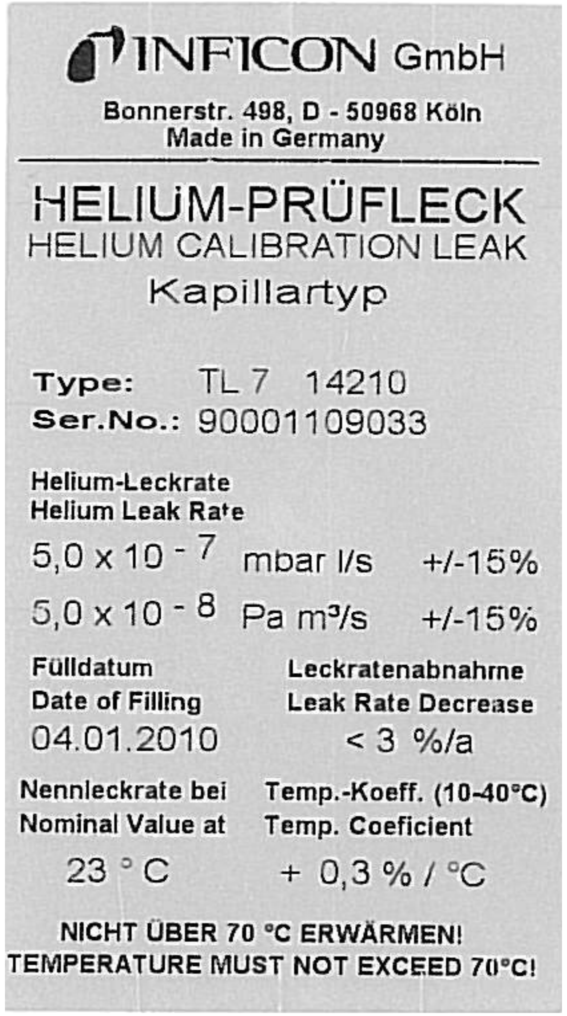
- Long time stability
- Large temp. coefficient (3.5% / °C)
- Recommendable only with a gas tank

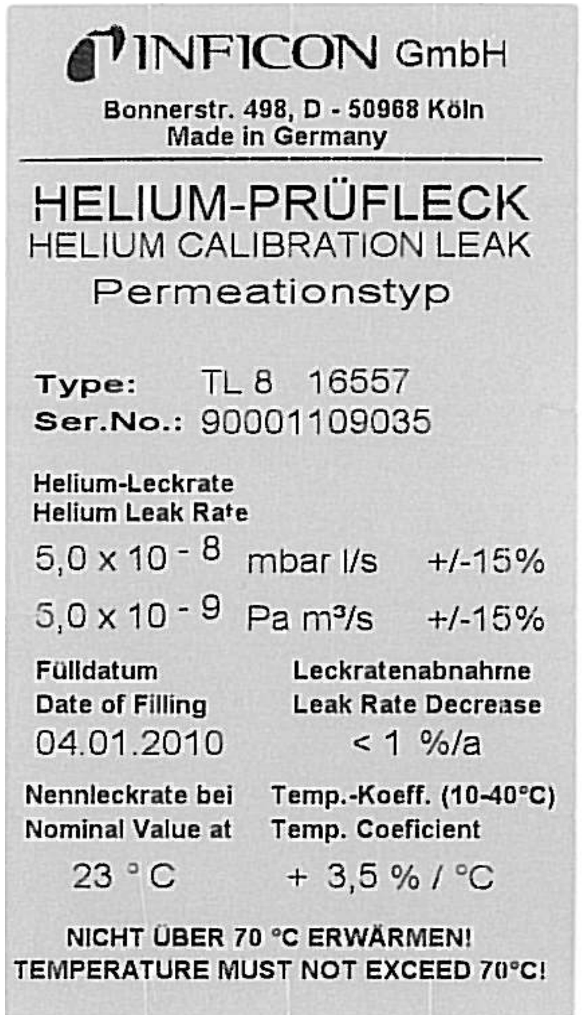
Capillary test leak:

- Small temp. coefficient (0,3% / °C)
- Short response time
- Clog easily

Calibration - and test leaks

Nameplates of Test Leaks





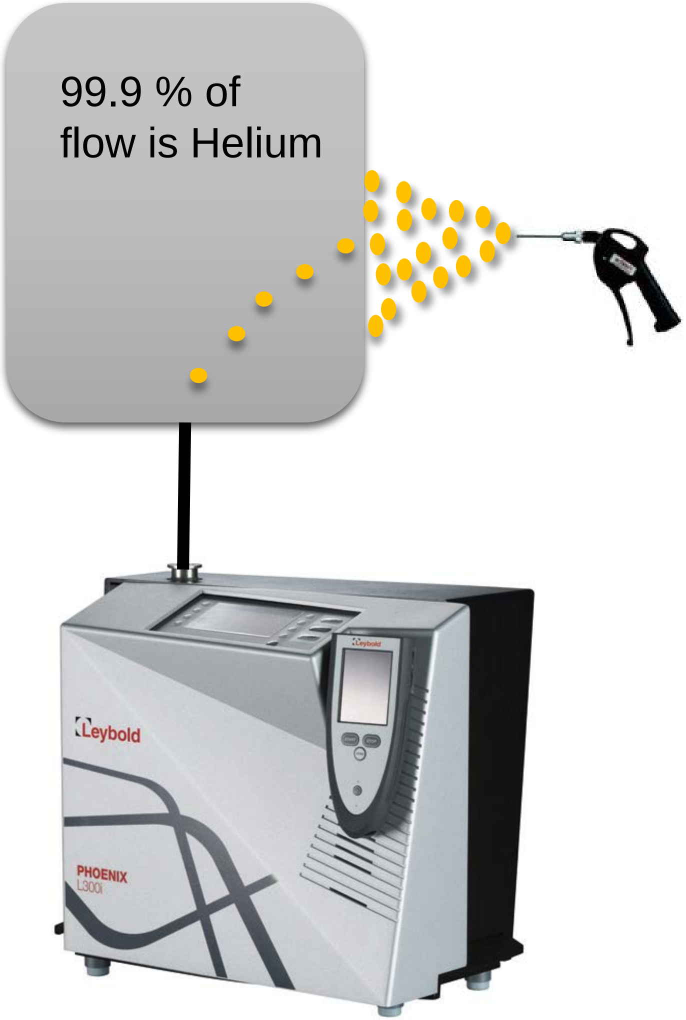
Calibration - and test leaks

Overview for Test leaks

- TL 4/TL 6: Capillary test leak without Gas support
- TL 4-6: Capillary test leak for sniffer and vacuum use
- TL 7: (internal) Capillary test leak
- TL 5: Capillary test leak for use in vacuum
- TL 8/TL 9: Permeation- (Diffusion-) test leak

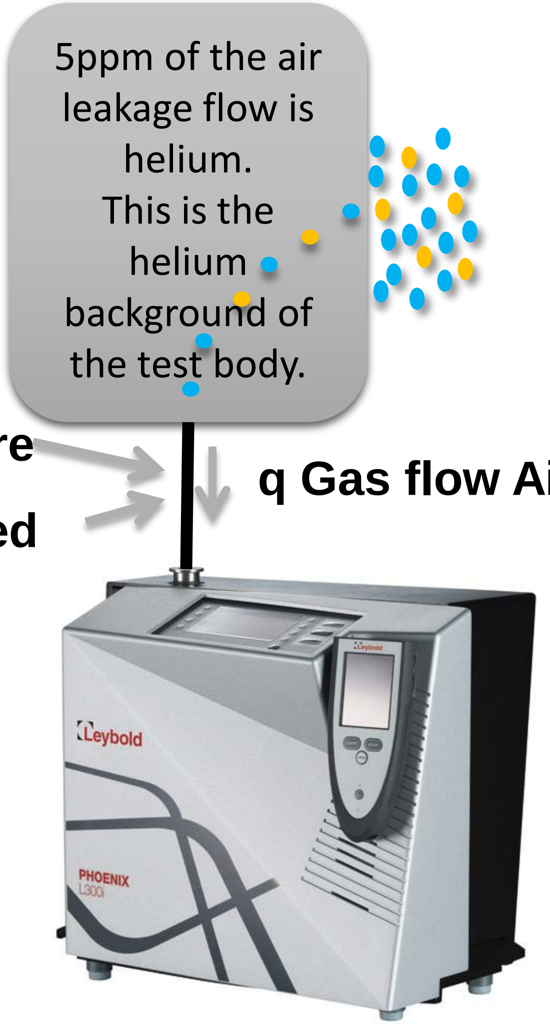
The Helium Background

He-Background vs. He-Leak rate



The Helium Background

Display – Background - Detection Limit



P Intake pressure

S Pumping speed

q Gas flow Air

Which helium background is to be expected?

$$q = p \cdot S$$

$$qHe = q_{Air} \cdot 5ppm$$

$$q_{He} = p \cdot S \cdot 5 \cdot 10^{-6}$$

What air leakage exists with given Helium background?

$$Air\ leakage\ qair = \frac{He - Background\ qHe}{5\ ppm}$$

$$Air\ leakage\ qair = qHe \cdot 2 \cdot 10^{5}\ mbar \cdot l/s$$

The Helium Background

Leybold

Terms / Examples

Measured signal:	➢ Leak and He from spraying
Background from Test object + tubing:	➢ Permeation from sealing's at growing He background e.g. tubing from elastomer ➢ Helium from the last test specially at big chambers or sealing's.
Leak detector background:	➢ Helium at the (rotary vane-) pump oil ➢ Helium at dead volumes from diaphragm pumps or in Elastomer sealing's
Zero point suppression:	➢ (or Zero point shifting) at digital displays maximum for 2 decades reasonable
Lowest detectable leak rate:	➢ smallest selectable signal above the electrical noise (Pumps al compressor; Stability of the electrical signal)

The Leak detector takes every back ground signal as a leak signal (and simply added). The reading is the Addition of He signal and He background (from Leak detector or test object).

The Helium Background

Counteraction He background

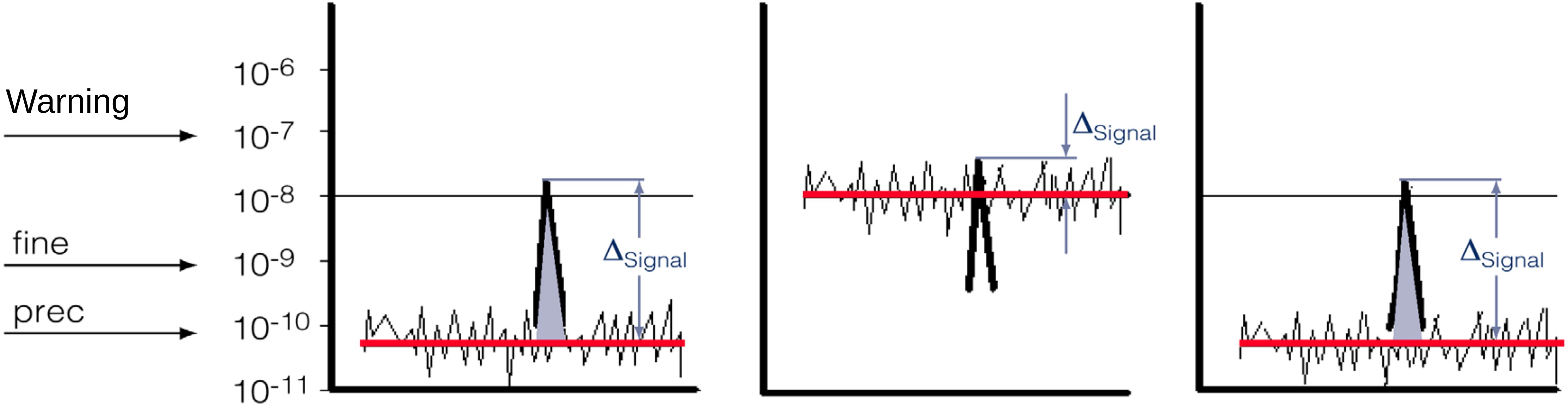
- Zero point suppression for better reading
- He background of the detector is working with an automatic „dynamic Zero point suppression“ also applicable with manual use of 0- button
- Gas ballast use for. 30 min
- 2 measurements are needed to indicate the right He leak rate.

    1. background of the test object without spraying Helium
    2. Helium Signal with 99.9 % Helium
    3. Building the difference of Helium signal minus background signal

- The He background should not be mixed up with the slowly decreasing He signal during switching the leak detector on the vacuum system.

The Helium Background

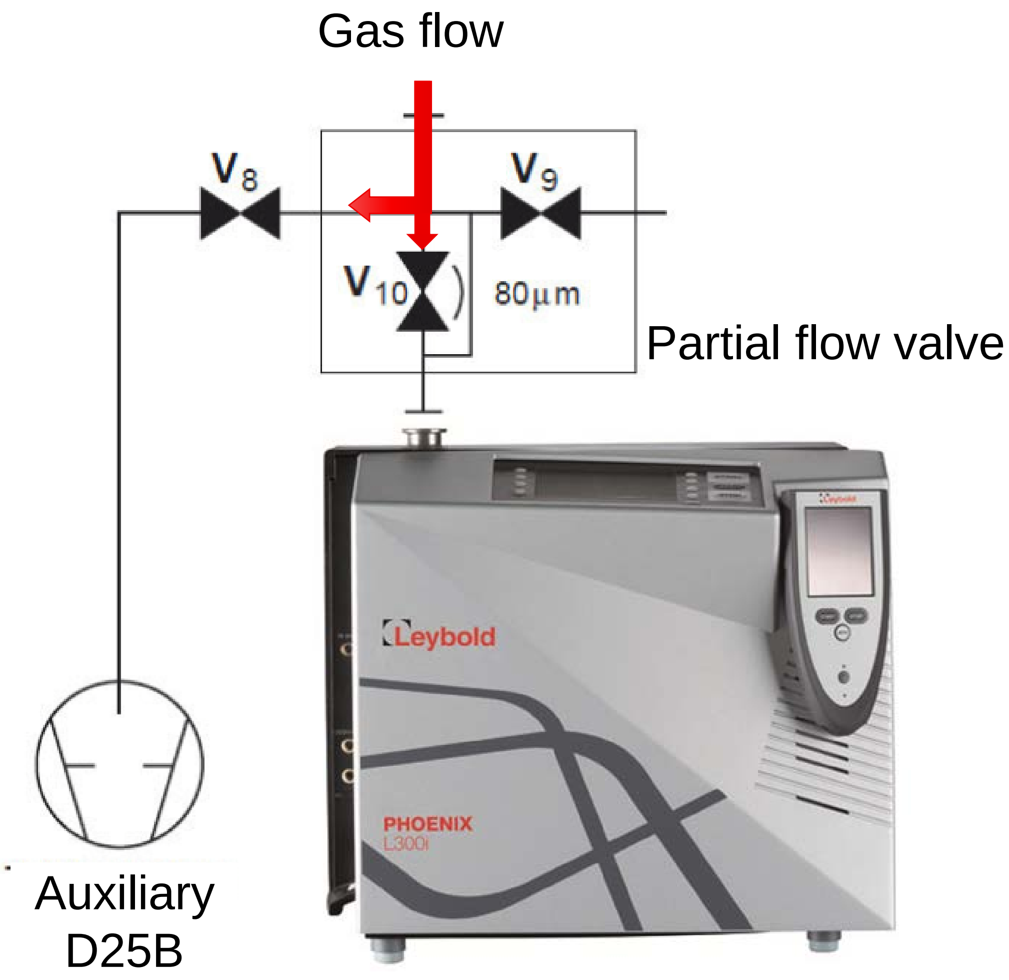
Zero point suppression



He background	$< 2 \cdot 10^{-10}$	$1 \cdot 10^{-8}$	$1 \cdot 10^{-8}$ suppressed with ZERO $<1 \cdot 10^{-10}$
Leak	$2 \cdot 10^{-8}$	$2 \cdot 10^{-8}$	$2 \cdot 10^{-8}$
Display	$2 \cdot 10^{-8}$	$3 \cdot 10^{-8}$	$2 \cdot 10^{-8}$

Partial flow operation

Leak detector with Partial Flow Set



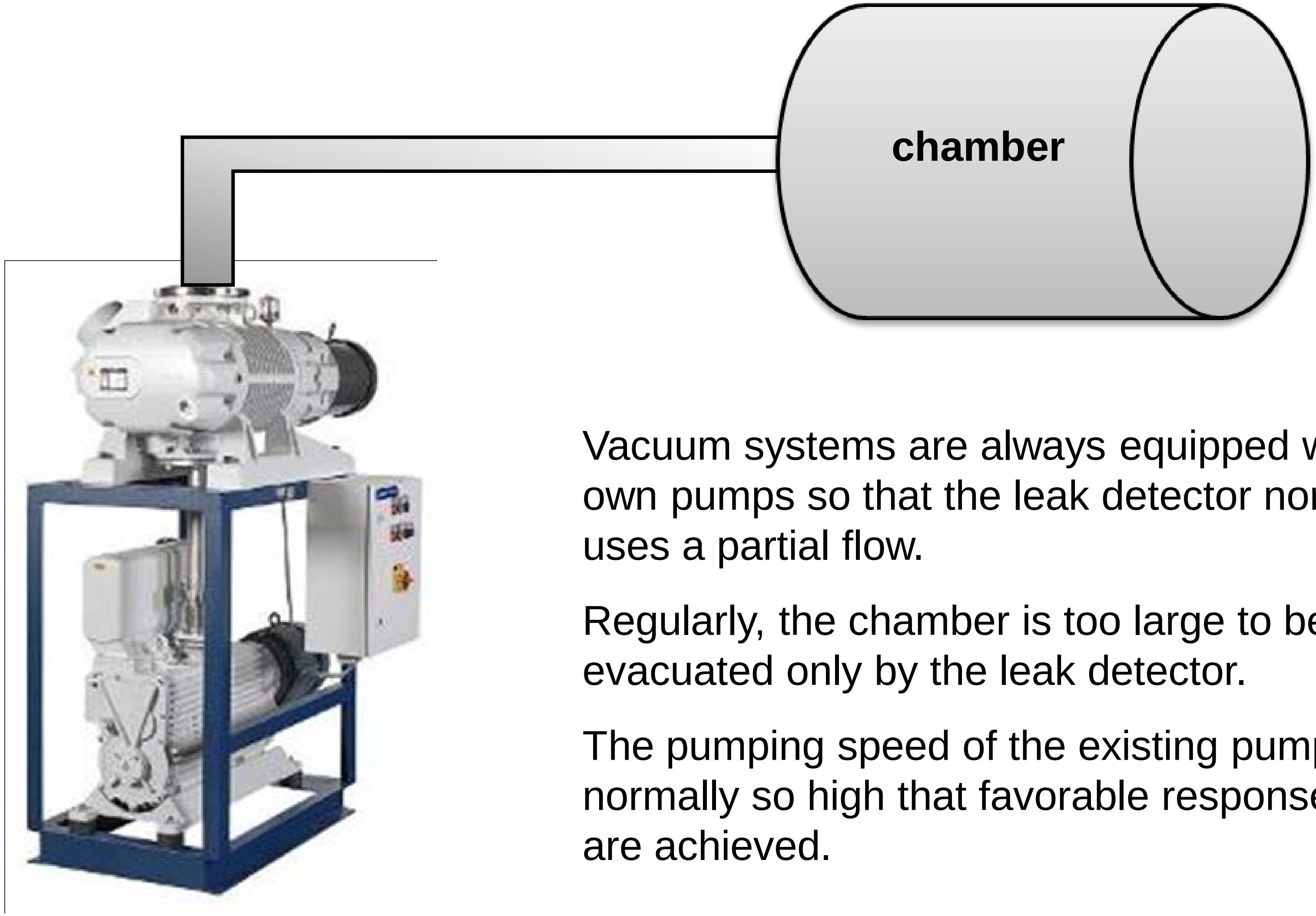
In partial flow operation, the test object is additionally evacuated by an auxiliary pump. A part of the gas flows through the auxiliary pump, a part to the leak detector. In sum, a higher pumping speed is available

Advantages:

- Faster measuring readiness
- Faster response time
- Fast flood of large test objects.

Partial flow operation

Leak detection at Vacuum systems



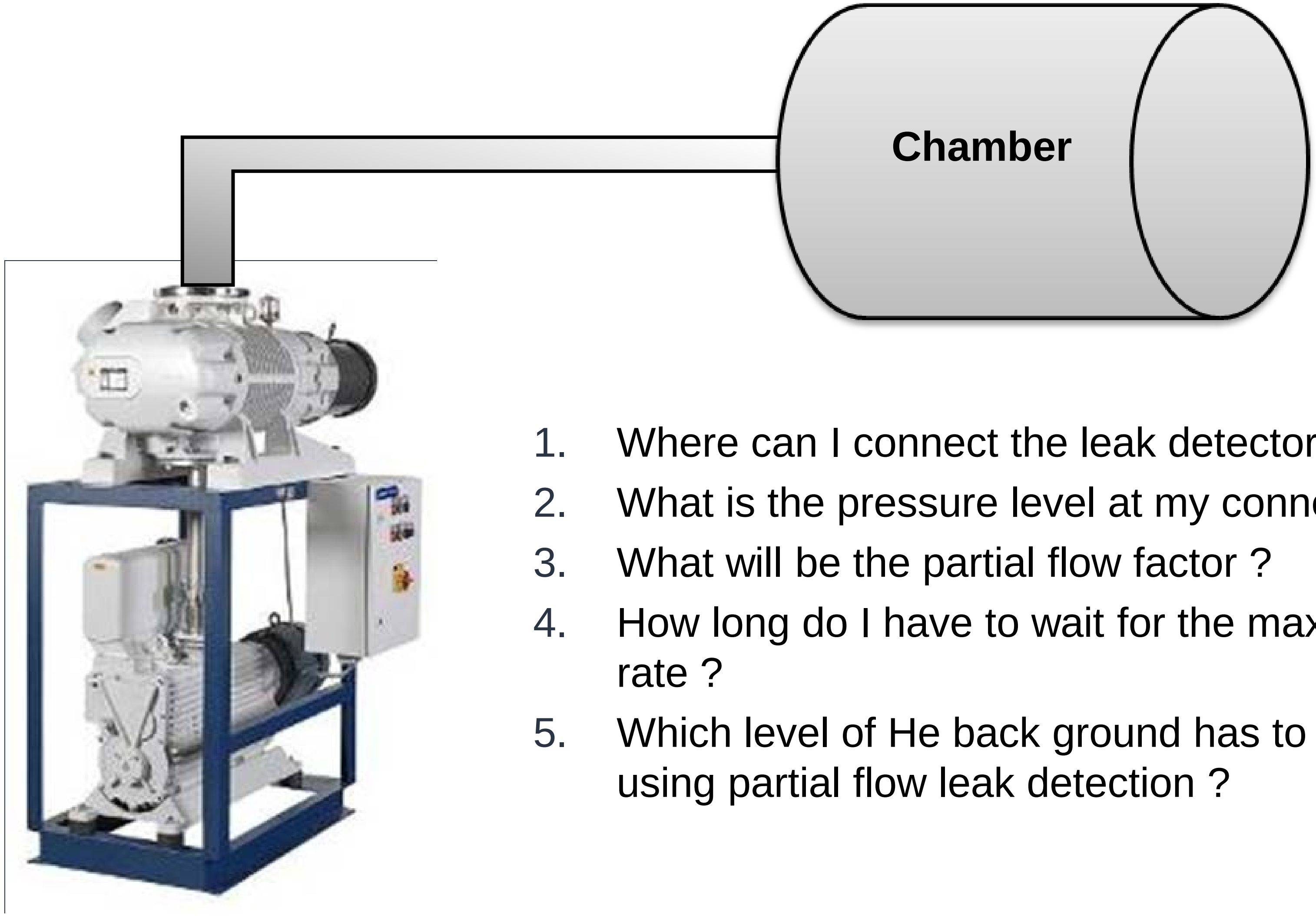
Vacuum systems are always equipped with their own pumps so that the leak detector normally uses a partial flow.

Regularly, the chamber is too large to be evacuated only by the leak detector.

The pumping speed of the existing pumps is normally so high that favorable response times are achieved.

Partial flow operation

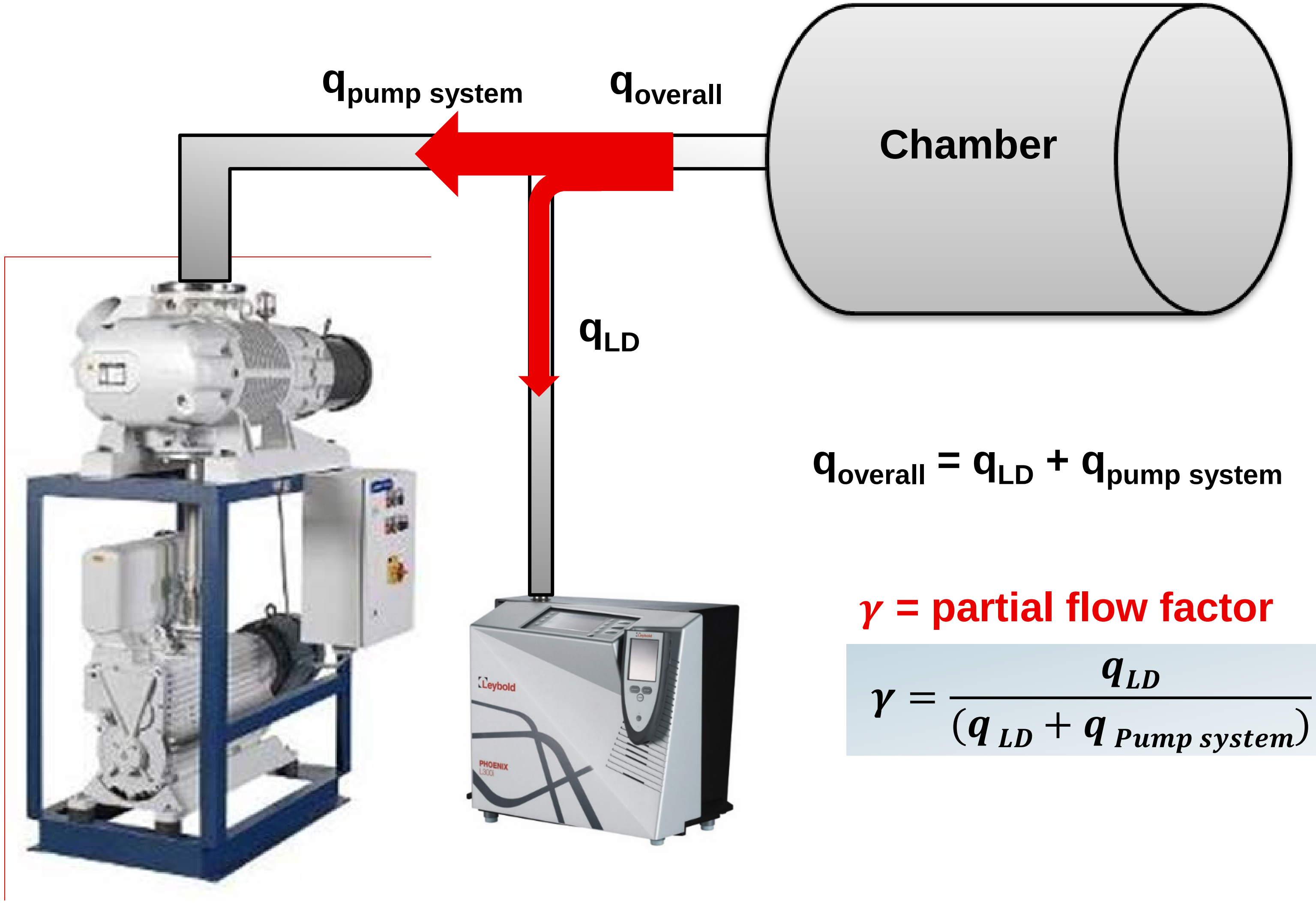
5 pre thoughts for partial flow leak detection at a vacuum system



1. Where can I connect the leak detector mechanically ?
2. What is the pressure level at my connecting flange ?
3. What will be the partial flow factor ?
4. How long do I have to wait for the max. reading of leak rate ?
5. Which level of He back ground has to be expected by using partial flow leak detection ?

Partial flow operation

Partial Flow System (1)

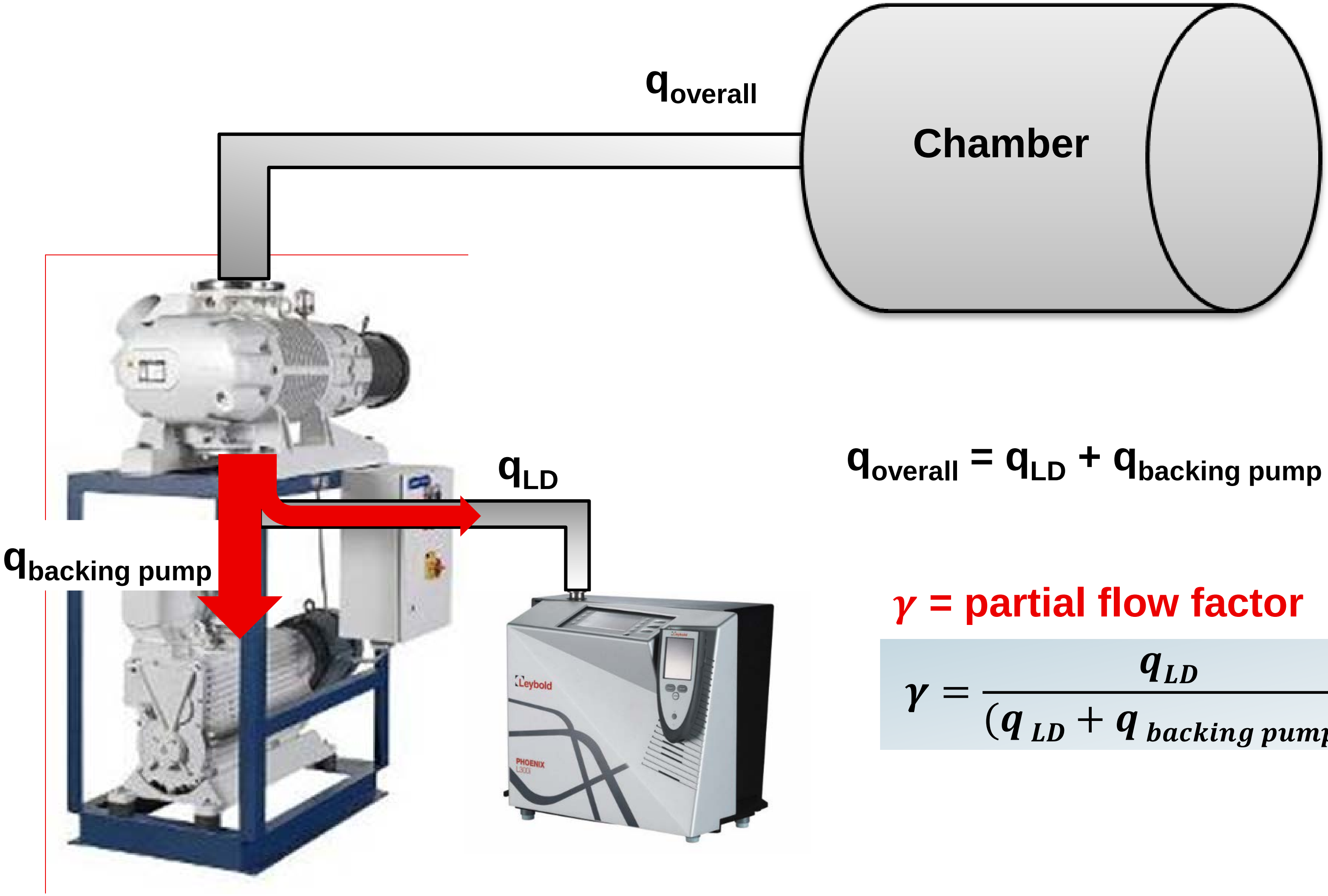


$$q_{overall} = q_{LD} + q_{pump\ system}$$

γ = partial flow factor

$$\gamma = \frac{q_{LD}}{(q_{LD} + q_{Pump\ system})}$$

Partial Flow System (2)



$q_{overall} = q_{LD} + q_{backing\ pump}$

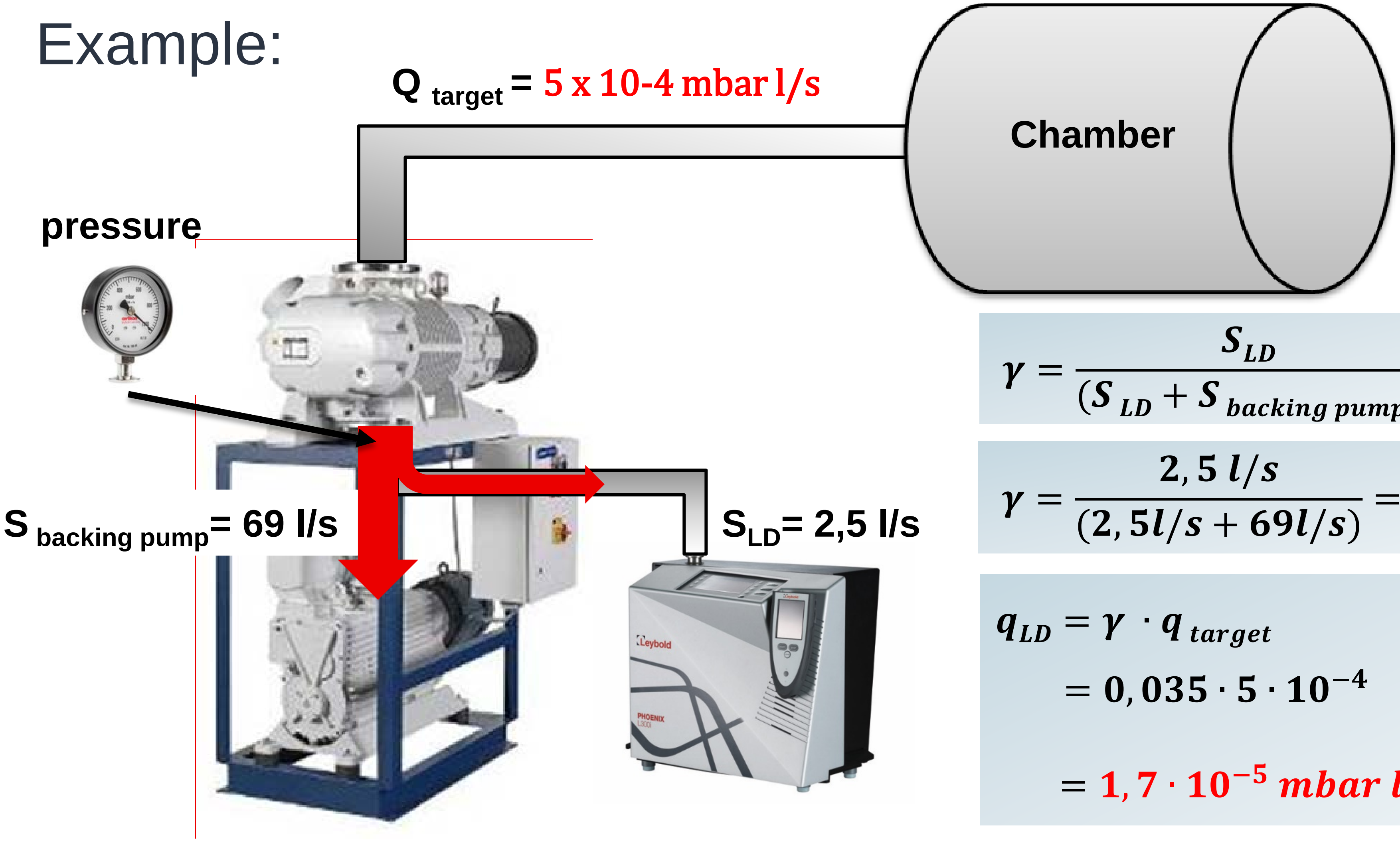
γ = partial flow factor

$$\gamma = \frac{q_{LD}}{(q_{LD} + q_{backing\ pump})}$$

Partial flow operation

Calculation of partial flow factor

Example:



$$\gamma = \frac{S_{LD}}{(S_{LD} + S_{backing\ pump})}$$

$$\gamma = \frac{2,5\ l/s}{(2,5 l/s + 69 l/s)} = 0,035$$

$$q_{LD} = \gamma \cdot q_{target}$$

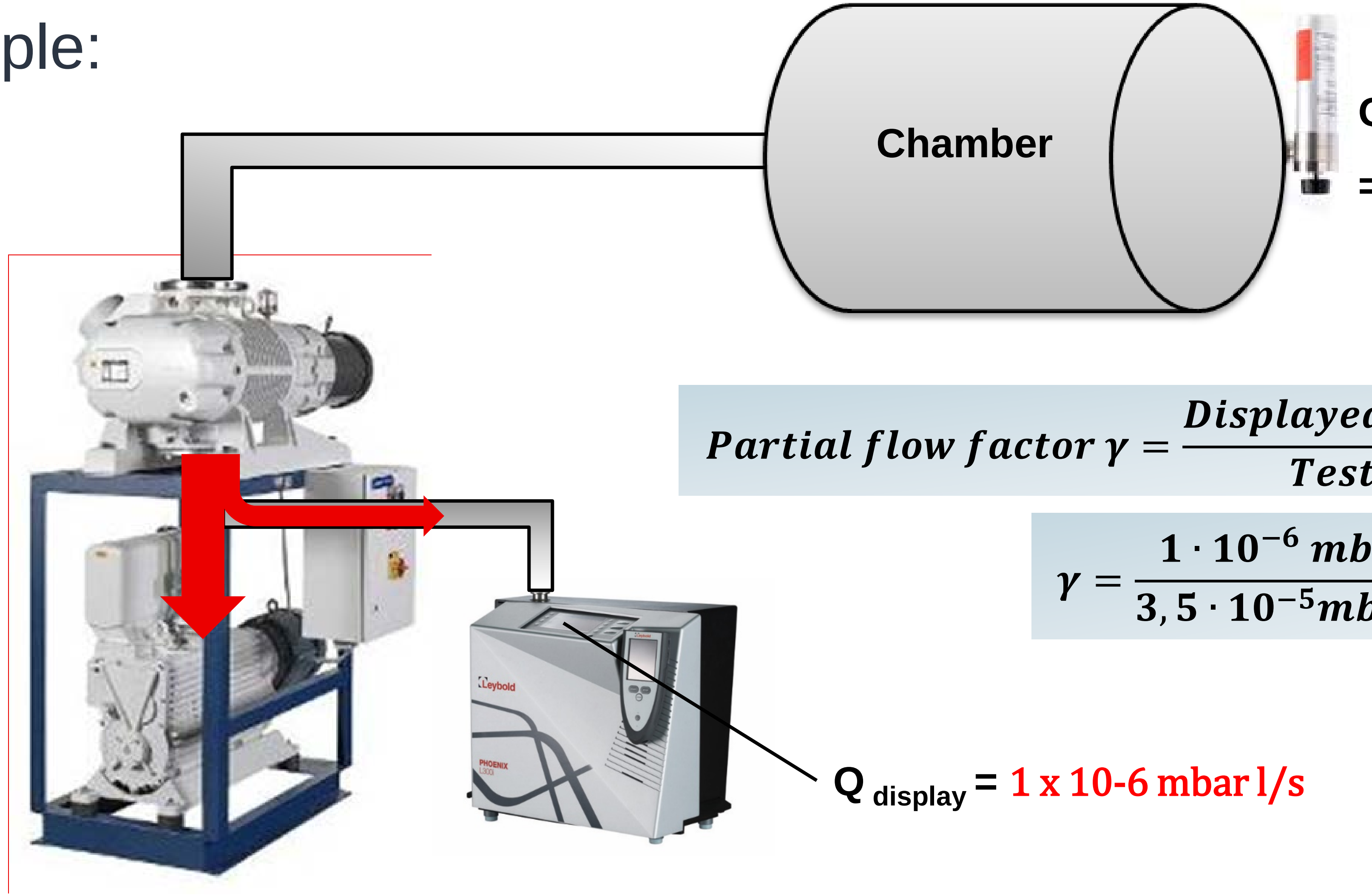
$$= 0,035 \cdot 5 \cdot 10^{-4}$$

$$= 1,7 \cdot 10^{-5}\ mbar\ l/s$$

Partial flow operation

Determination of partial flow factor with a test leak

Example:



$Q_{\text{Test leak}}$ = 3,5 x 10-5 mbar l/s

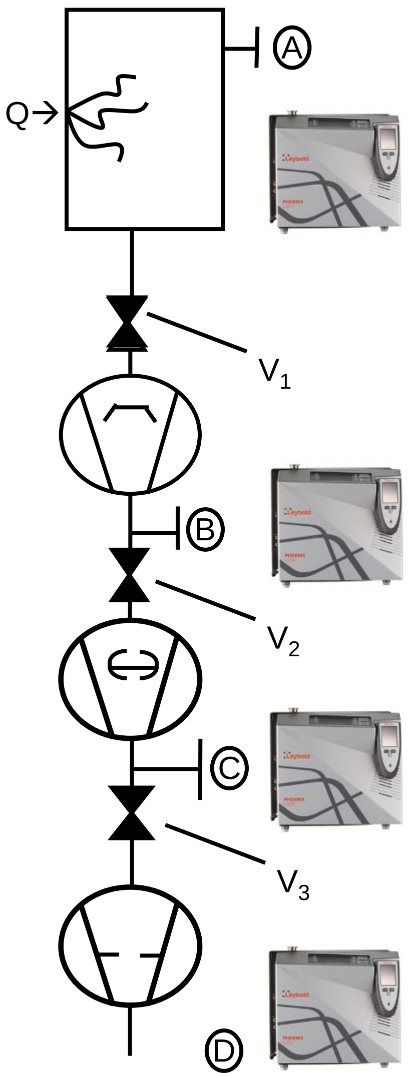
$$Partial\ flow\ factor\ \gamma = \frac{Displayed\ leak\ rate}{Test\ leak}$$

$$\gamma = \frac{1 \cdot 10^{-6}\ mbar\ l/s}{3,5 \cdot 10^{-5} mbar\ l/s)} = 0,028$$

Q_{display} = 1 x 10-6 mbar l/s

Partial flow operation

Connect leak detector to the pump system



Connection A (V1 closed)
The leak detector can not evacuate the chamber sufficiently.
The sensitivity is good, but the pressure and thus the Helium background remain high. The response time is too high.

Connection A (V1 open)
The pump system evacuates the chamber and reaches with a low end pressure also a low Helium background.
The sensitivity is significantly reduced by the partial flow ratio.

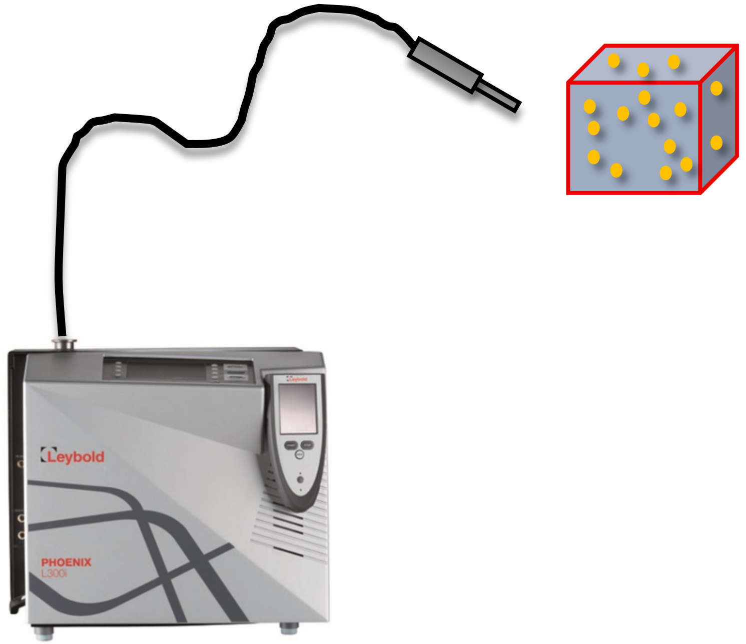
Connection B
The pressure and He background are larger as compared to A.
The sensitivity is improved by a more favorable partial flow ratio.

Connection C
The pressure and He background are larger in comparison with B.
The sensitivity is improved by a more favorable partial flow ratio.

Connection D (sniff)
The He background is 5ppm.
The sensitivity and response time are not good.

Principle of Sniffing leak detection

Basics



In the case, that a test object is under helium pressure, only the sniffing method can be used for the local leak detection.
Method B4: Local leak detection (sniffing).

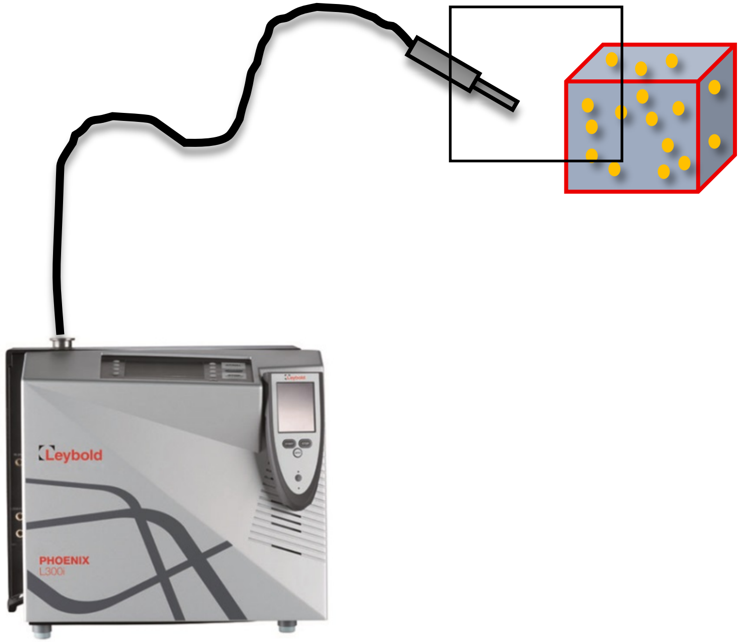
Principle of Sniffing leak detection

Some thoughts of the sniffing method

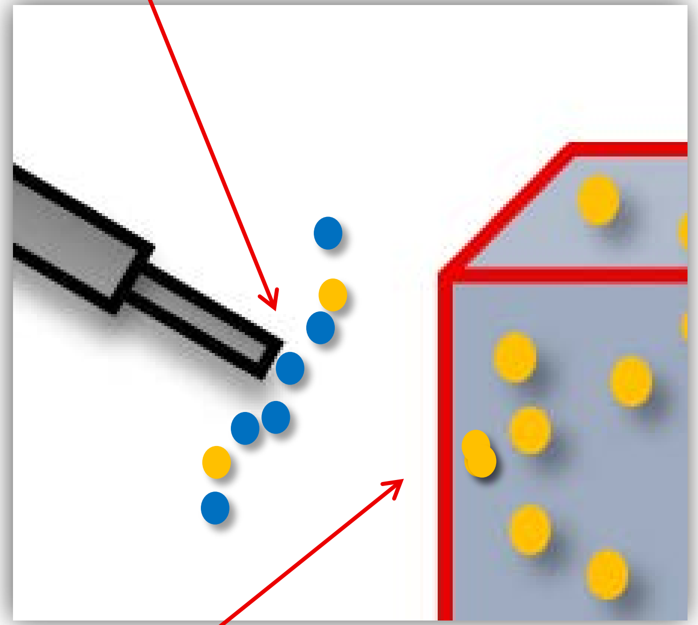
- the He concentration on air is app. 5 ppm (parts per million).
- The He part on air causes a natural Helium background signal of app. 2 - 5 · 10-6 mbar · l / s
- A Helium contamination of the ambient air will influence the He background signal. As a result the smallest detectable He rate will rise also.
- The speed and the distance of the sniffer tip will have influence to the displayed leak rate.
- The displayed leak rate is not automatically the real leak rate. Mostly you have to do a pressure correction.

Principle of Sniffing leak detection

Ambient conditions for sniffing



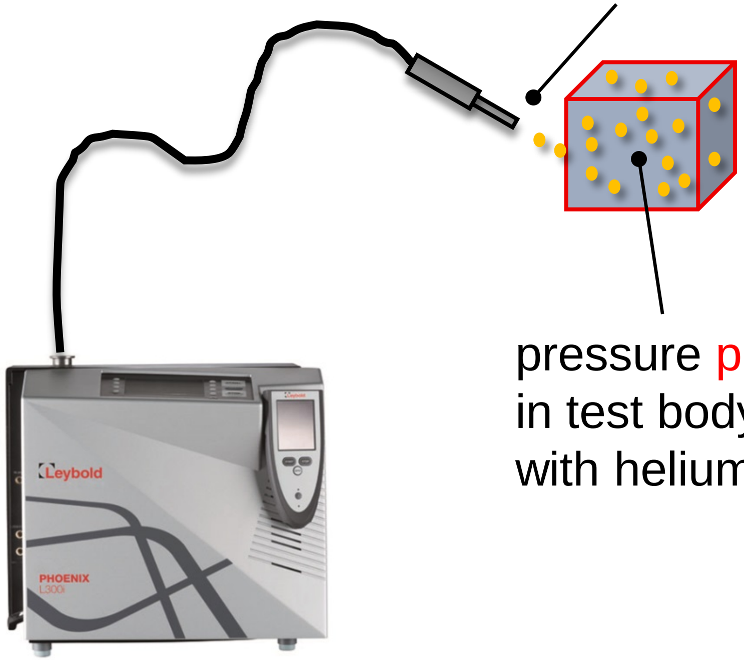
5ppm helium and air will be pumped through the sniffing tip into the leak detector



In addition, the helium out of the leak will be pumped into the leak detector. Now, the total helium concentration is greater than 5ppm

Principle of Sniffing leak detection

Calculations for sniffing He leak detection



$Q_{\text{standard leak rate } 1\rightarrow 0} = q_{\text{under test conditions } p2\rightarrow p1} / (p_2^2 - p_1^2)$

Example:

test pressure = 6 bar (absolute)

measured leak rate = $1{,}0 \cdot 10^{-4}$ mbar · l / s,

than is Standard leak rate

$q_{N1\rightarrow 0}$ = $1{,}0 \cdot 10^{-4}$ mbar · l / s / (6² bar – 1²bar)

= $1{,}0 \cdot 10^{-4}$ mbar · l / s / (36 bar – 1bar)

= $1{,}0 \cdot 10^{-4}$ mbar · l / s / 35

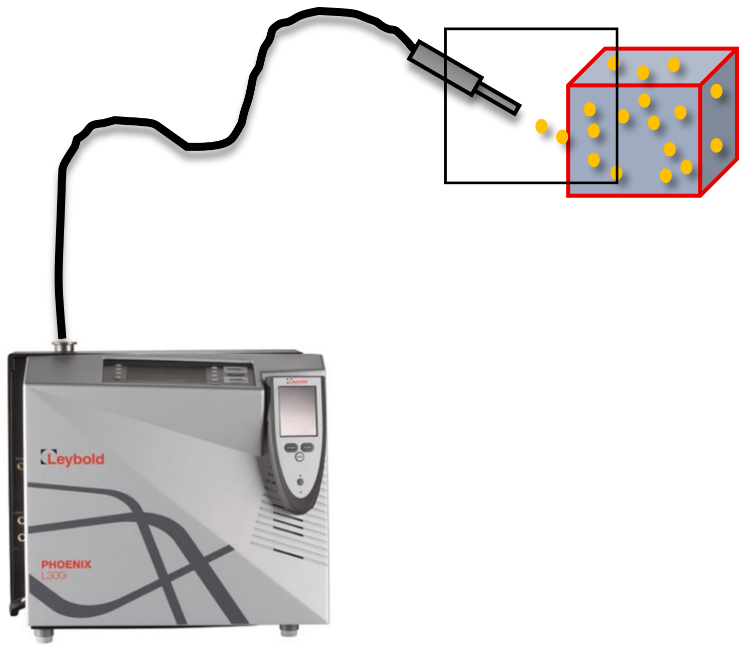
= $2{,}9 \cdot 10^{-6}$ mbar · l / s

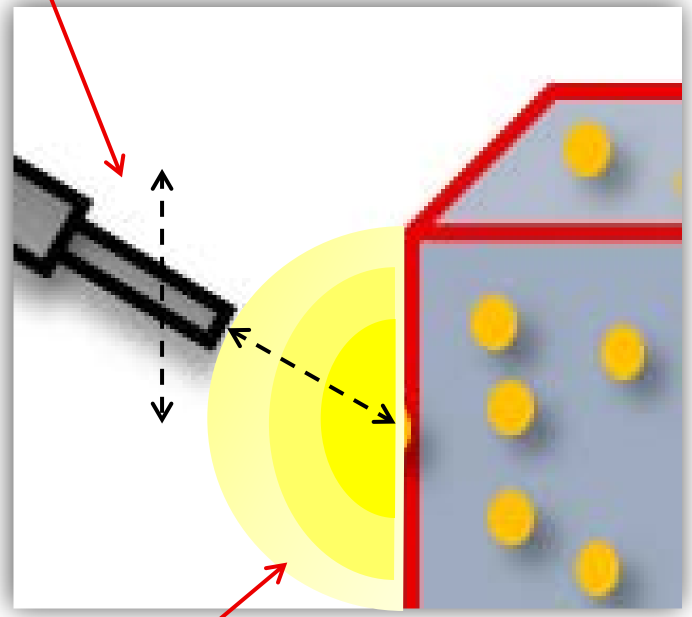
It is often sufficient to divide the measured leak rate by the square of the test pressure

Principle of Sniffing leak detection

Influence to the measured Leak rate

The speed of passing the leak has an influence to the size of the helium peak. As higher the speed of movement as smaller the recognized leak.





The displayed leak rate will be reduce with a hyperbolic function related to the distance of the leak.

Principle of Sniffing leak detection

Sniffing lines

1. The standard sniffer line is designed with a length of **4 m** so that it can be connected directly to the vacuum inlet of the leak detector. At the LD itself, a reduced pressure as atmospheric pressure arises due to the line length and the line diameter. This pressure is about 1mbar. This is achieved with an air-gas throughput of approximately **q = 0.2 mbar l / s.**
2. The technology can no longer be realized with longer cable lengths of **10 m** and **20 m** even up to **50 m**. Such line lengths necessarily have a dead time during the signal display. This should be as short as possible for the operator. For this reason, an auxiliary pump (diaphragm) with continuous gas delivery and a relatively large air-gas flow of approx. **q = 2 mbar l / s** is used here. (QT 100) The gas inlet is effected by a helium-permeable diaphragm.

Quick-Test QT 100

Thank you for your attention!