Monitoring Gas Pressure in Vacuum Insulation Panels

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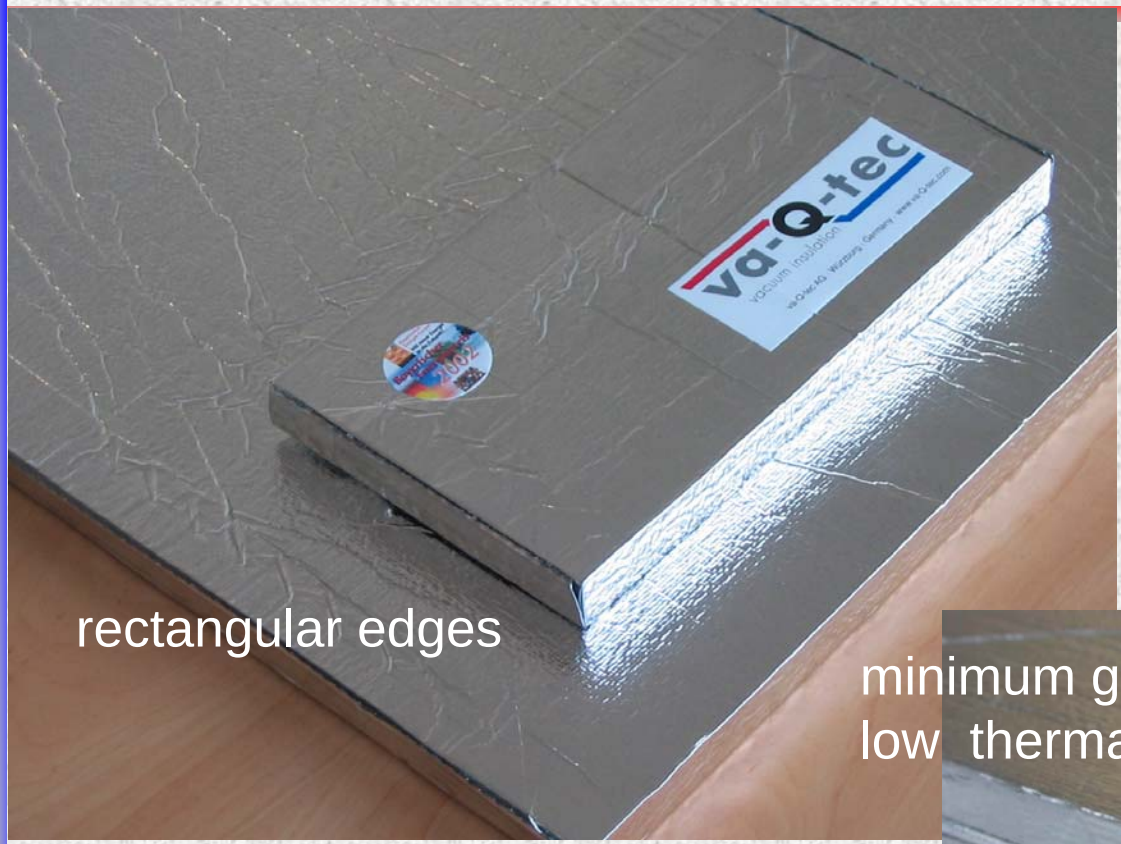
va-Q-tec AG:

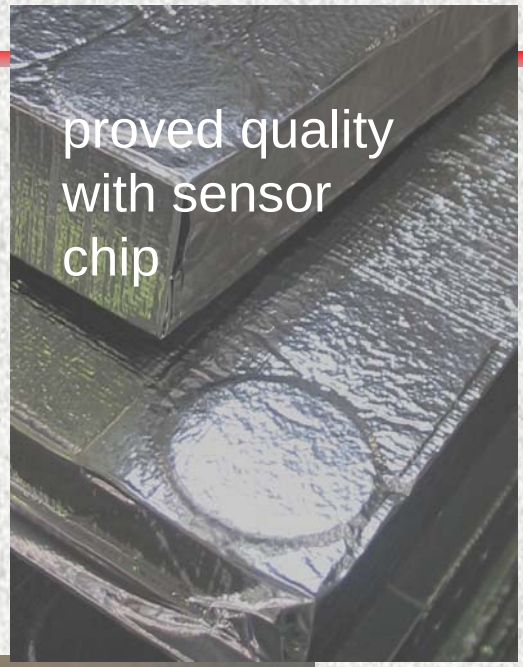
- production of vacuum insulation panels
- research and development
- application of vacuum insulation panels

  to buildings, cold chain logistics, refrigeration

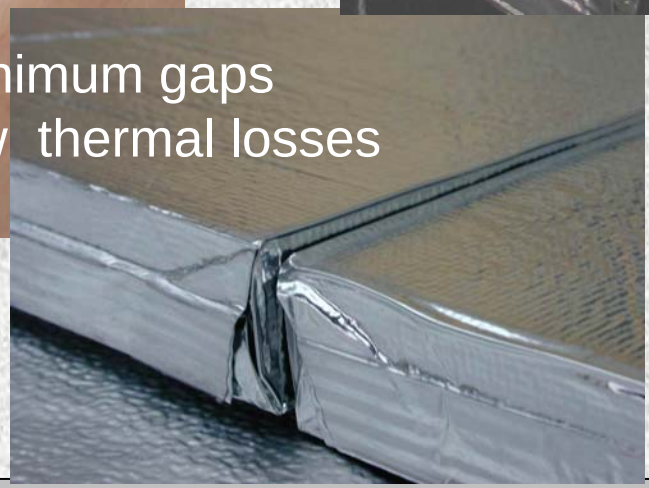
VIPs from va-Q-tec



rectangular edges



proved quality
with sensor
chip



minimum gaps
low thermal losses

VIPs from va-Q-tec

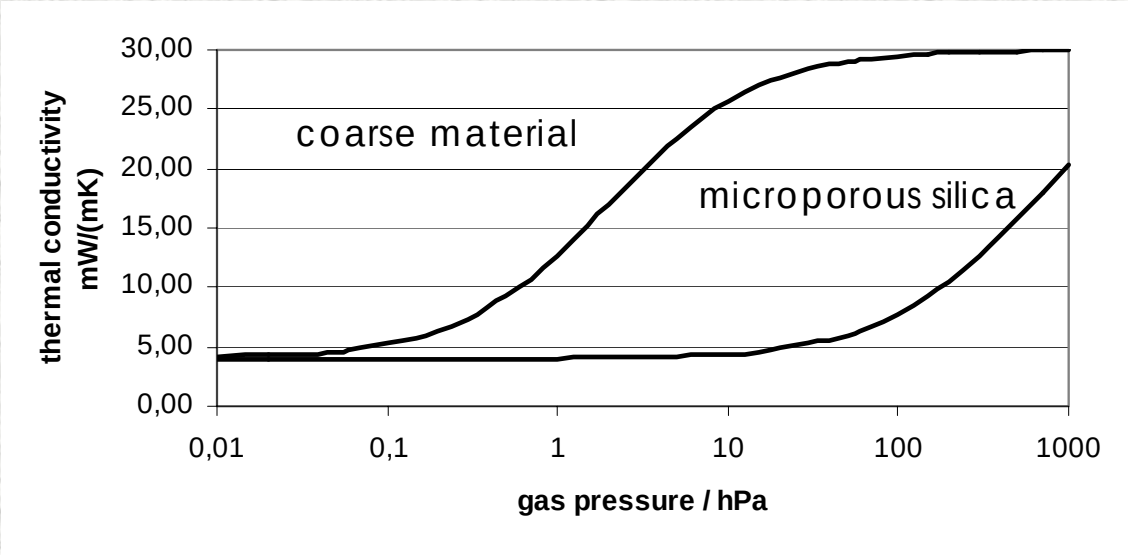
with different core materials

		mW/(mK)
fumed silica:	long life time especially for buildings	4 – 5
micro fleece:	low conductivity for transport boxes	2,6 – 3,5
PU-foam:	low density for boxes, refrigerators	7 – 9

Quality Control of Vacuum Insulation Panels

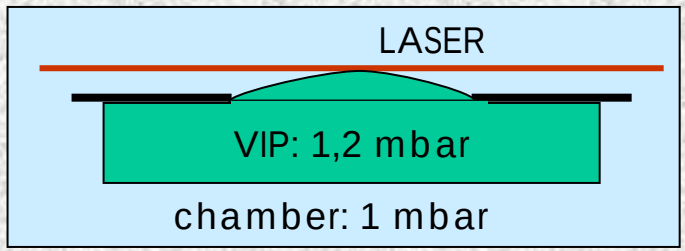
Indicator of VIP quality:
thermal resistance after production
influenced by => **actual gas pressure**

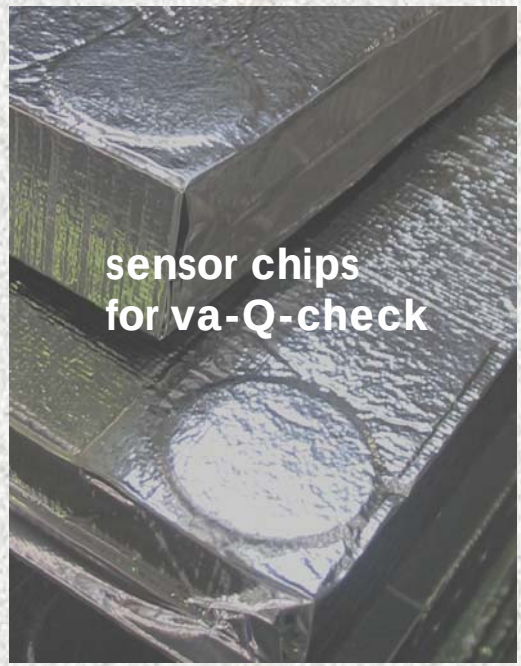
durability of thermal resistance, long service life
dependent on => **change of gas pressure with time**



Methods of Gas Pressure Measurement

- **vacuum chamber method**
- **spinning rotor gauge**
- **va-Q-check system**
- **internal sensor**
- **thermal conductivity measurements with coarse filler material**



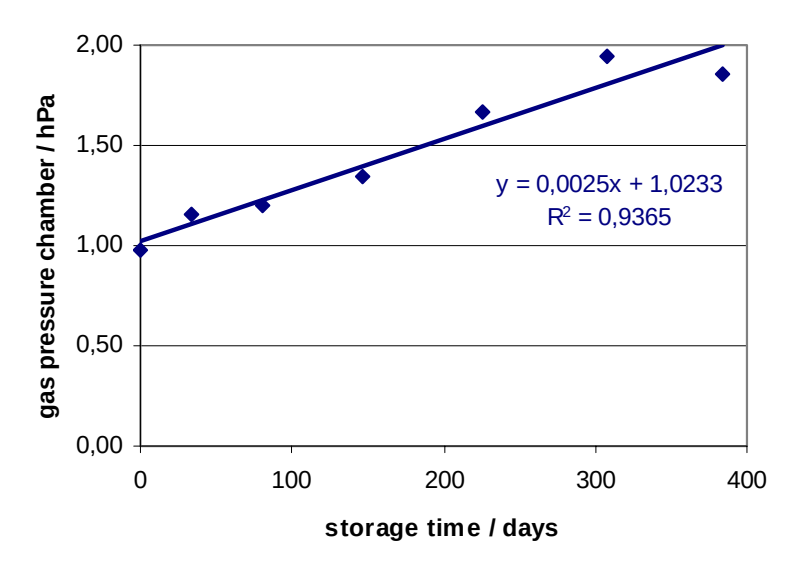


storage of VIPs under different conditions: temperature, humidity, gas

Vacuum Chamber Method

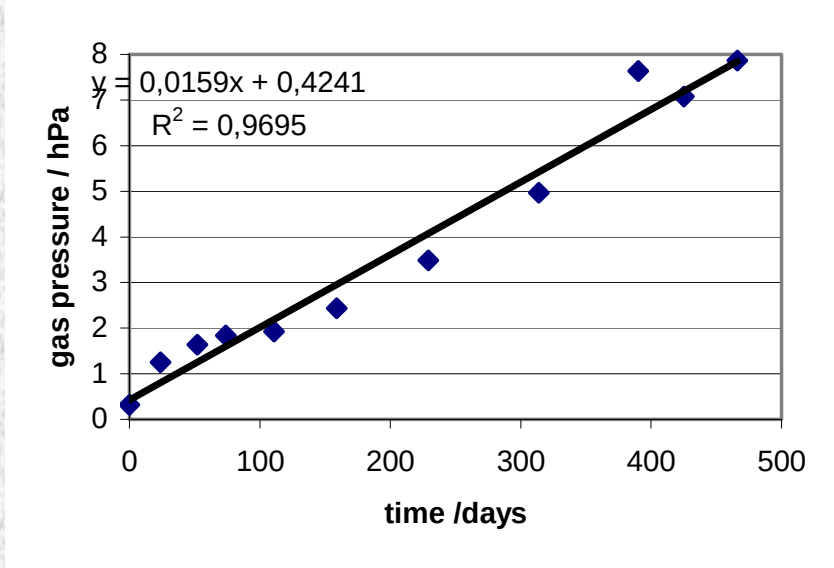
Examples:
20 mm VIPs with fumed silica and metallized film

stored at **room temperature**



increase: 1 hPa per year

stored at **80 °C**



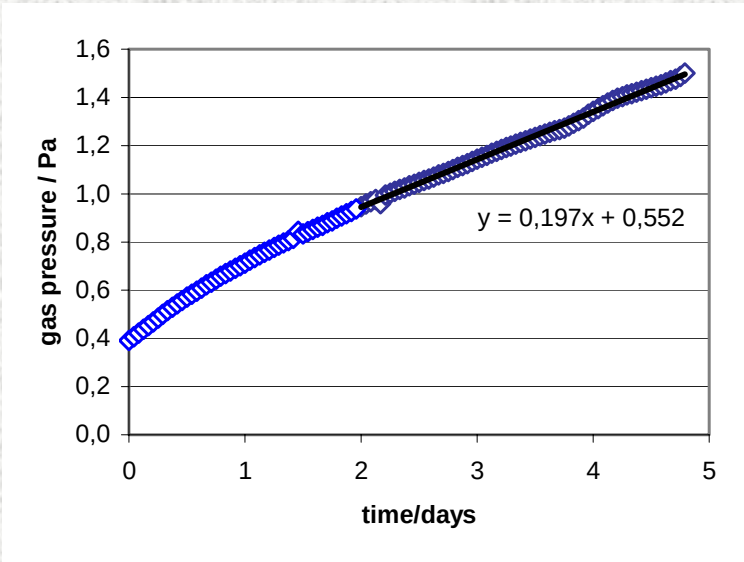
6 hPa per year

Spinning Rotor Gauge

Steel tube with spinning steel ball is attached to vacuum panel
External device measures deceleration of rotation frequency => depends on gas pressure

sample: VIP with coarse filler material and metallized film

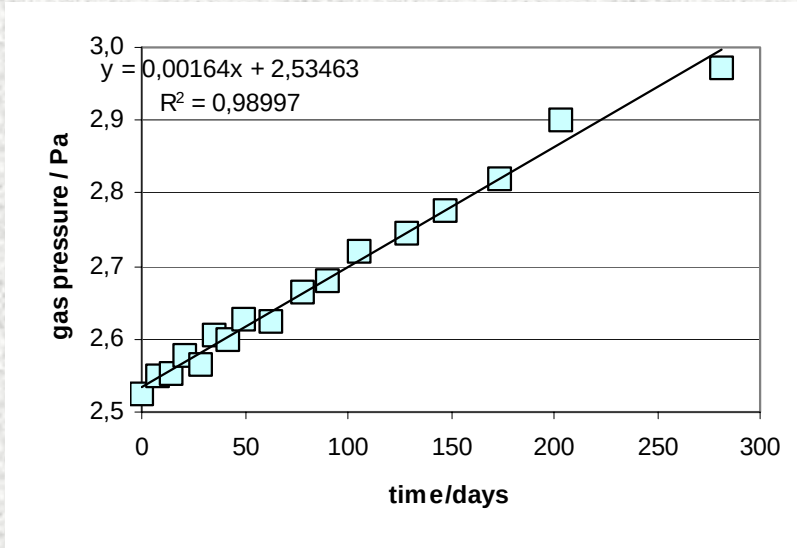
stored at **room temperature**



rate of gas pressure increase:

72 Pa per year

stored at **– 30 °C**

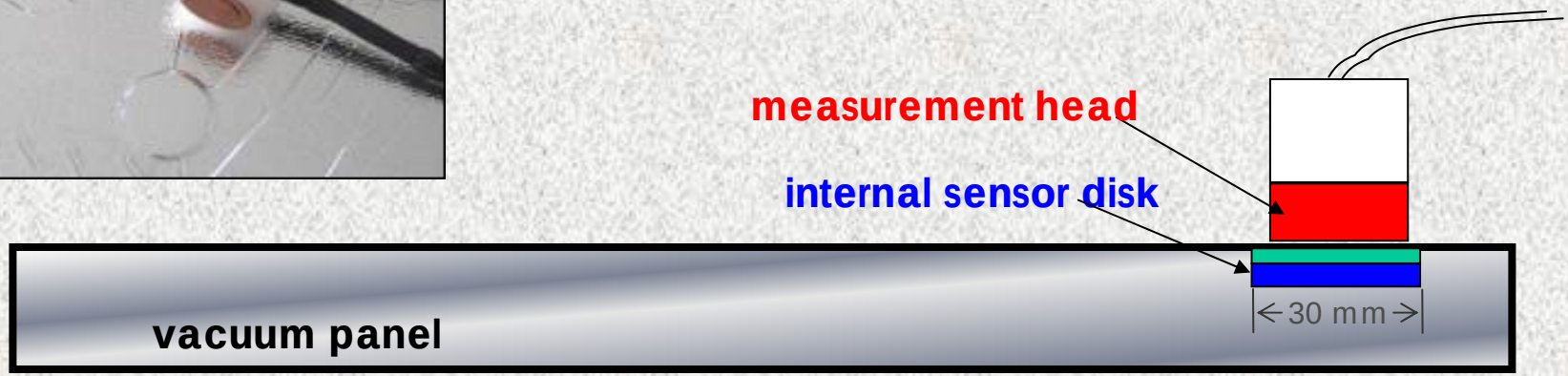


0,6 Pa per year

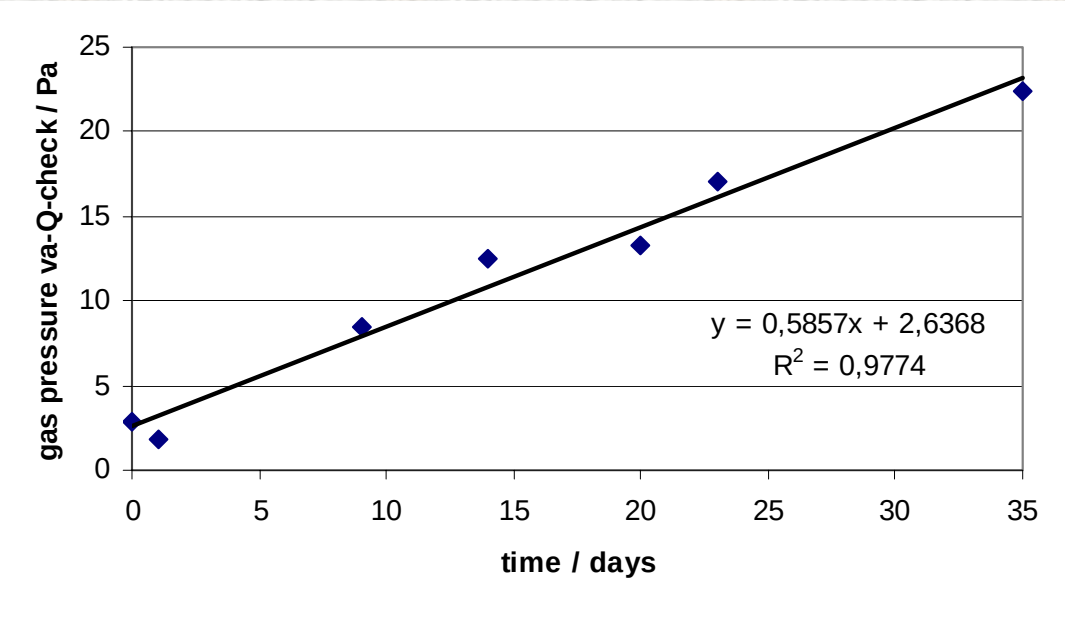
Gas Pressure Measurement with „va-Q-check“

measurement device: miniature head for heat flux measurement
thermal conductivity of internal thin fleece is measured
measurement range : 0,02 mbar up to 10 mbar

advantage: easy sample preparation, fast measurement (5 -10 s)



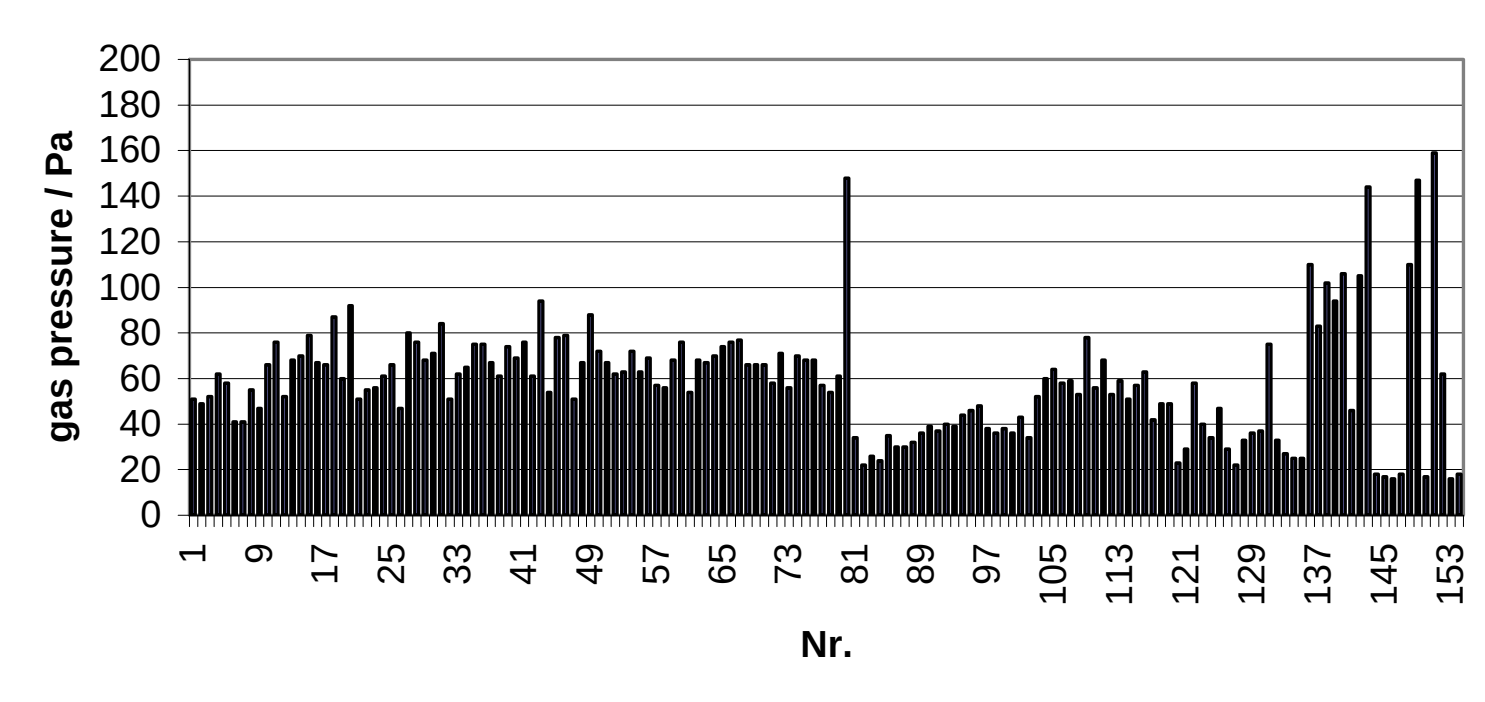
Measurement of Gas Pressure Increase with va-Q-check



sample: VIP with 5 mm thickness, metallized film, coarse filler material and dryer

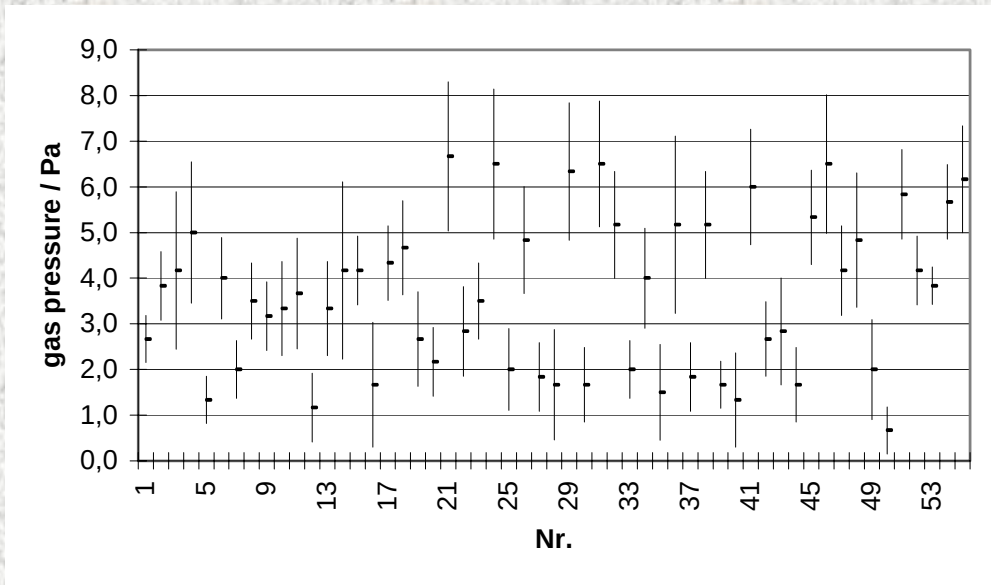
gas pressure increase: here 2 hPa per year, can be verified after two or three weeks

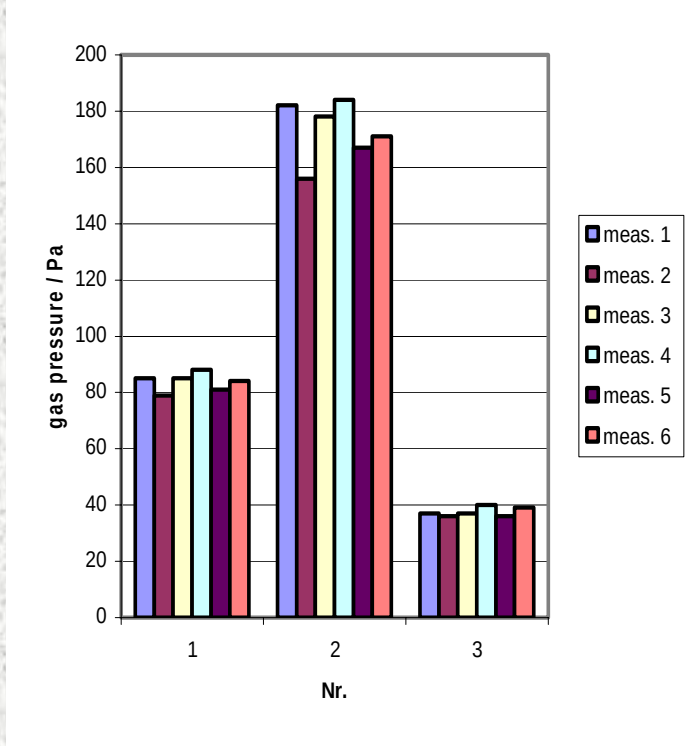
Production Control with va-Q-check



samples: fumed silica VIPs 1000 mm x 500 mm x 20 mm with metallized film
maximum allowed gas pressure: 3 hPa
mean gas pressure: about 0,5 hPa

Production Control with va-Q-check





samples:
VIPs with fiber filling and metallized film
three persons measured gas pressure twice within two days
mean values and standard variations are depicted above

repeated measurements with 3 samples at higher gas pressure

gas pressure is well below 0,1 hPa!

Storage within Helium Atmosphere

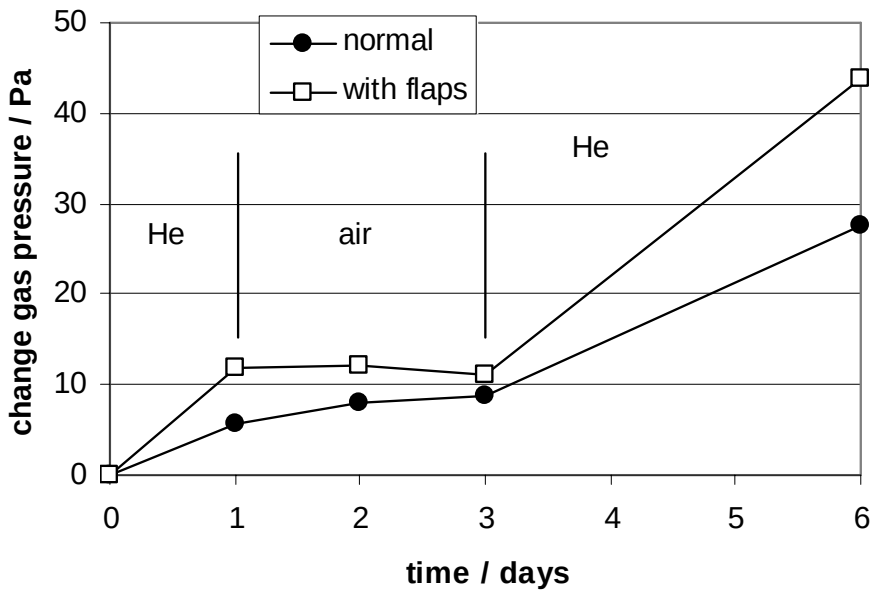
problem: how to measure fast gas pressure increase within fumed silica VIPs

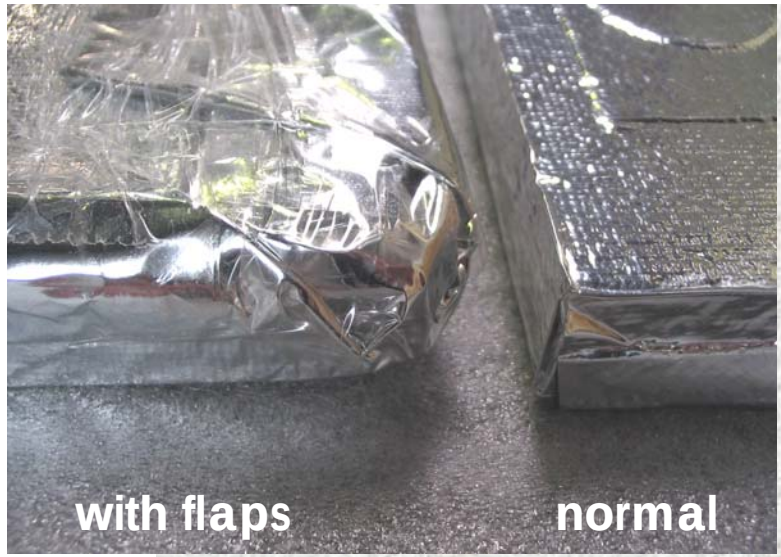
solution: storage of VIPs in He, gas pressure measurement with va-Q-check

example: 50 fumed silica VIPs panels with different envelope techniques

1 + 3 days exposed to He and 2 days exposed to air

result: VIPs with accurate folding (without flaps) have lower (He) gas pressure increase

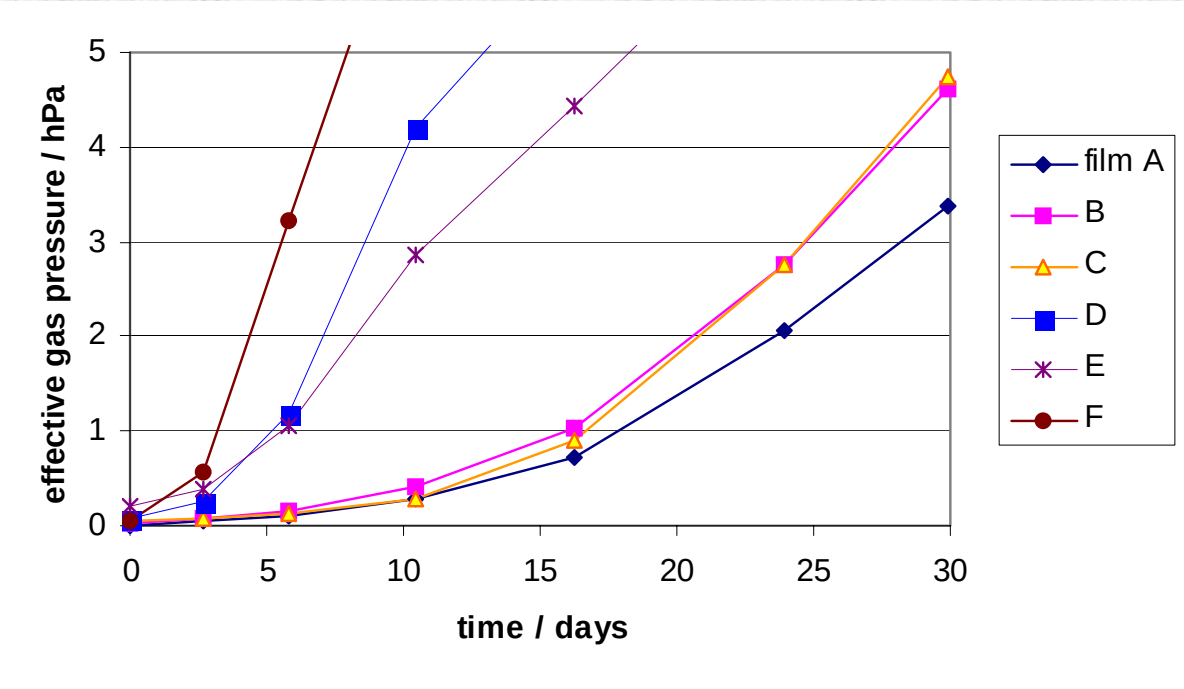




Storage in High Humidity Atmosphere

problem: how to measure water vapour transmission of different films in short time
solution: storage of VIPs with non-adsorbent filler at high humidity climate

example: increase of va-Q-check signal of VIPs with 6 different films
(measurement at room temperature in dry condition)
no absolute values; only relative comparison of VIPs is possible!



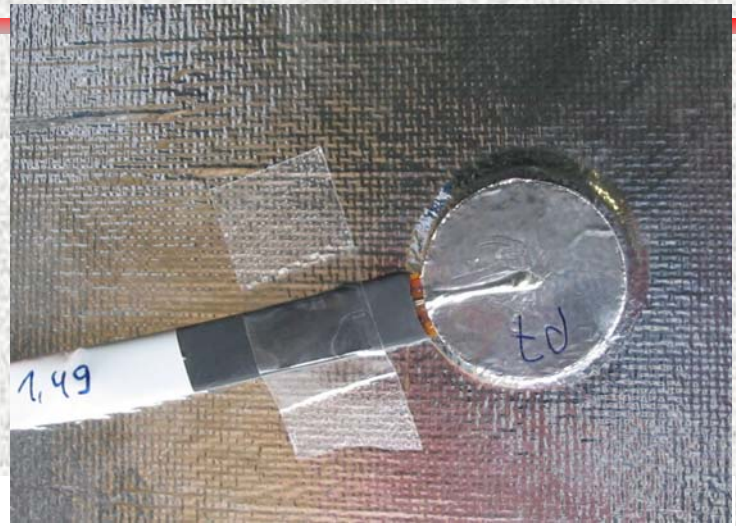
Permanent Measurement Head

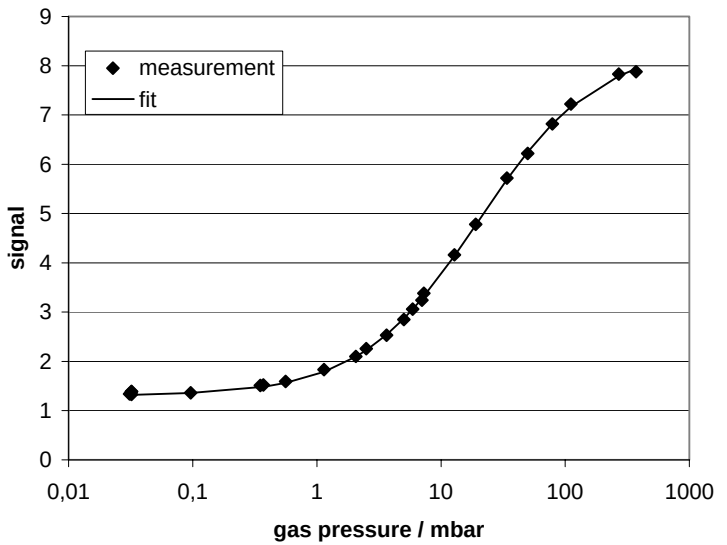
va-Q-check measurement head is permanently installed on VIP e.g. in house wall

1 mm thin measurement head!

connection to measurement device with 8 wires and plug

heating to operating temperature within 10 seconds, then usual measurement routine is started





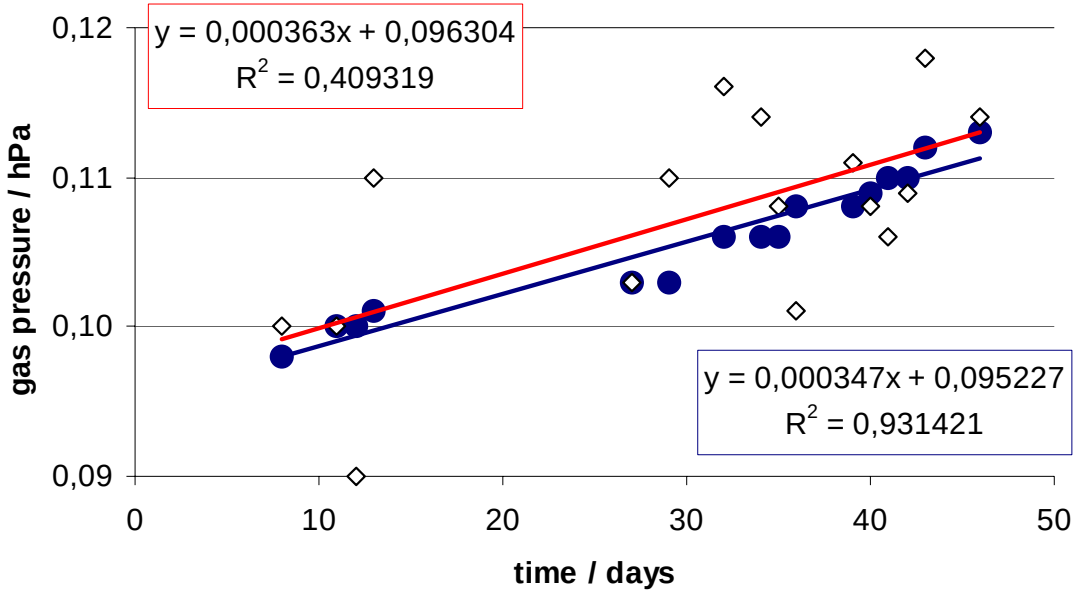
calibration curve with fine fleece, measurement range here is up to 100 hPa

Internal Thermal Sensor for Gas Pressure Measurement

sensor: heating foil suspended within small metal casing

wires for power input and temperature sensor are led through the seam of VIP

comparison of internal sensor and va-Q-check measurement



sample: VIP with coarse filler, dryer and **aluminium laminate foil**
results: internal sensor (blue dots) has far lower variation of gas pressure than va-Q-check (open dots)

gas pressure increase: 0,13 hPa per year

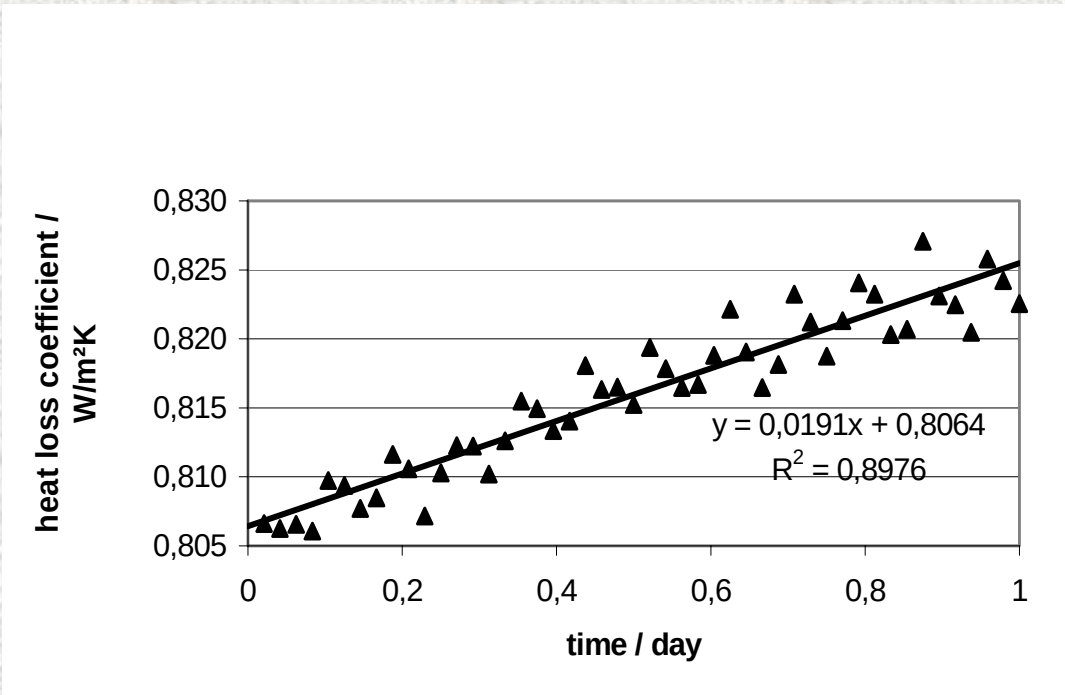
Gas Pressure Increase by Thermal Conductivity Measurement

problem: detecting gas pressure increases in very short time
solution: measurement of increase of thermal conductivity in VIP with coarse filler material

example: 5 mm x 400 mm x 400 mm VIP with coarse filler, dryer and metallized film
measurement of heat loss coefficient with heat flow meter apparatus

result:
gas pressure increase
2,7 hPa per year

measurement time:
1day

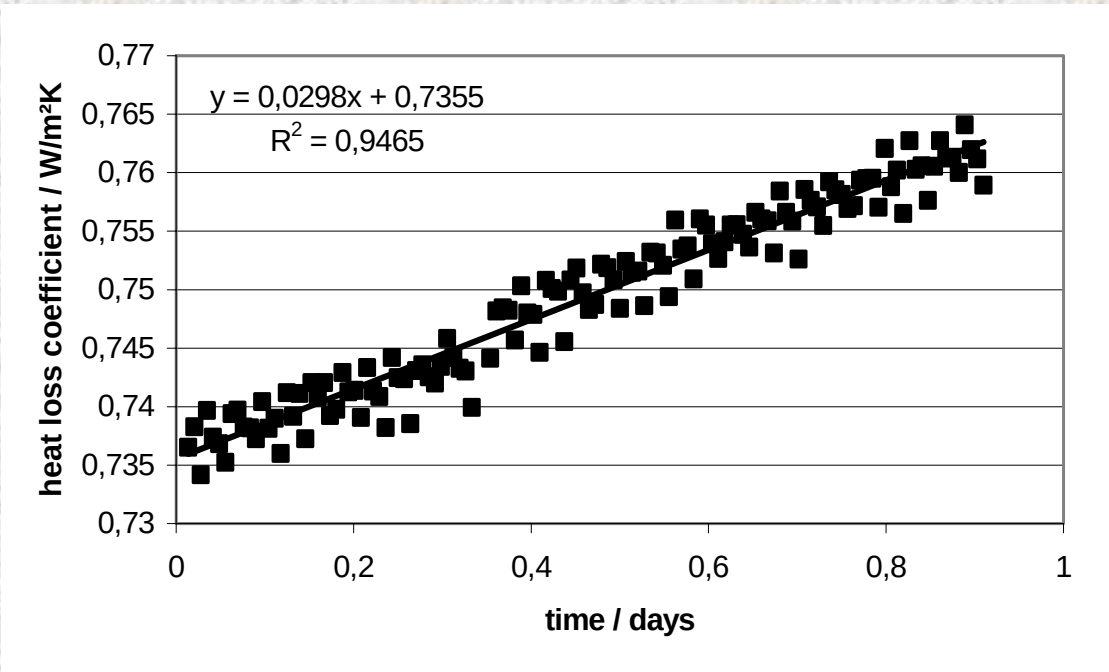


Thermal Conductivity Measurement with Helium Atmosphere

problem: detecting very low leakage within short time
solution: VIP stored in **He during measurement** of thermal conductivity

example: similar VIP as before, but with **aluminium foil** as envelope

result: increase of heat loss coefficient of 0,03 W/m²K per day easily detectable



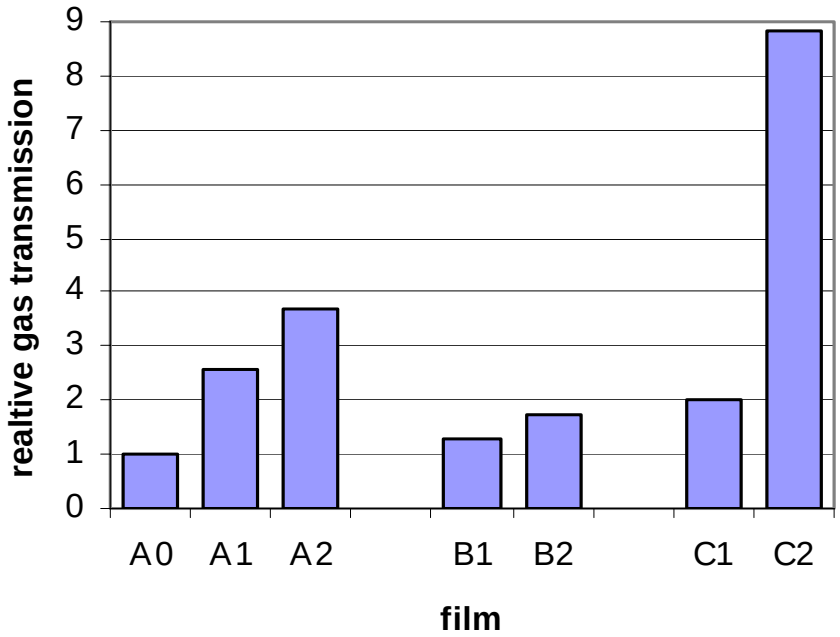
Application of Gas Pressure Measurements to Quality Control of Films

problem: how to control film quality after delivery

solution: produce sample VIPs with coarse filler and test increase of gas pressure with va-Q-check and by thermal conductivity (under different conditions)

example: three different high barrier films (A, B, C) with different delivery dates (0, 1, 2) va-Q-check measurement

results: quality of films may vary significantly!



Conclusions

- several fast methods for measurement of gas pressure and gas pressure increase in VIPs have been developed and tested
- a 100 % production control is essential for high VIP quality
- transmission of air, helium and water vapour through high barrier films can be measured by using appropriate test VIPs within one day and several weeks
- besides fumed silica better and controlled VIP products are also possible with glass fibers, open porous foams and powders

Thank you for your attention!