DESIGN AND CHARACTERIZATION OF REFRIGERANT REFERENCE LEAKS

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Motivation

Kyoto Protocol → Reduce fluorinated refrigerant gases

European Regulation No 842/2006 → Identifies the leak tightness as the key point to reach it

Commission Regulation No 1516/2007 → Installations with more than 3kg of refrigerants gases must be controlled periodically by refrigerant detectors with detection limits of 5g/year

How should the leak detectors sensitivity be checked?

Leak detectors qualification

EN 14624

Their sensitivity is checked with a

<u>Calibrated Leak</u>

Device with a defined mass flow rate of a given gas under defined pressure and temperature conditions.

Types of reference leaks

- Capillary leaks
- Permeation leaks

A permeation leak establishes its flow by a diffusion process across a barrier composed of a material which is permeable to the gas or vapor of interest.

Vacuum leaks

- *debit to vacuum*
- *composed only by gas*
- *vacuum leak metrology is well established*

Sniffer leaks

- *debit to atmosphere*
- Both phases (vapor and liquid) at saturation vapor pressure
- *Less established as vacuum leaks metrology*

Objective

The purpose is to design R134a (1,1,1,2-Tetrafluoroethane) permeation leaks.

We want to design R134a calibration leaks with a leak flow rate minimum of 5g/year.

What variables we need to define, to control?

1. *Specifications of the components and characterization of the leaks*
2. Filling the vials
3. Verify their leak rate

Permeation leaks characterization

$$Q = Pe\frac{A.\Delta p}{d}$$

Where:

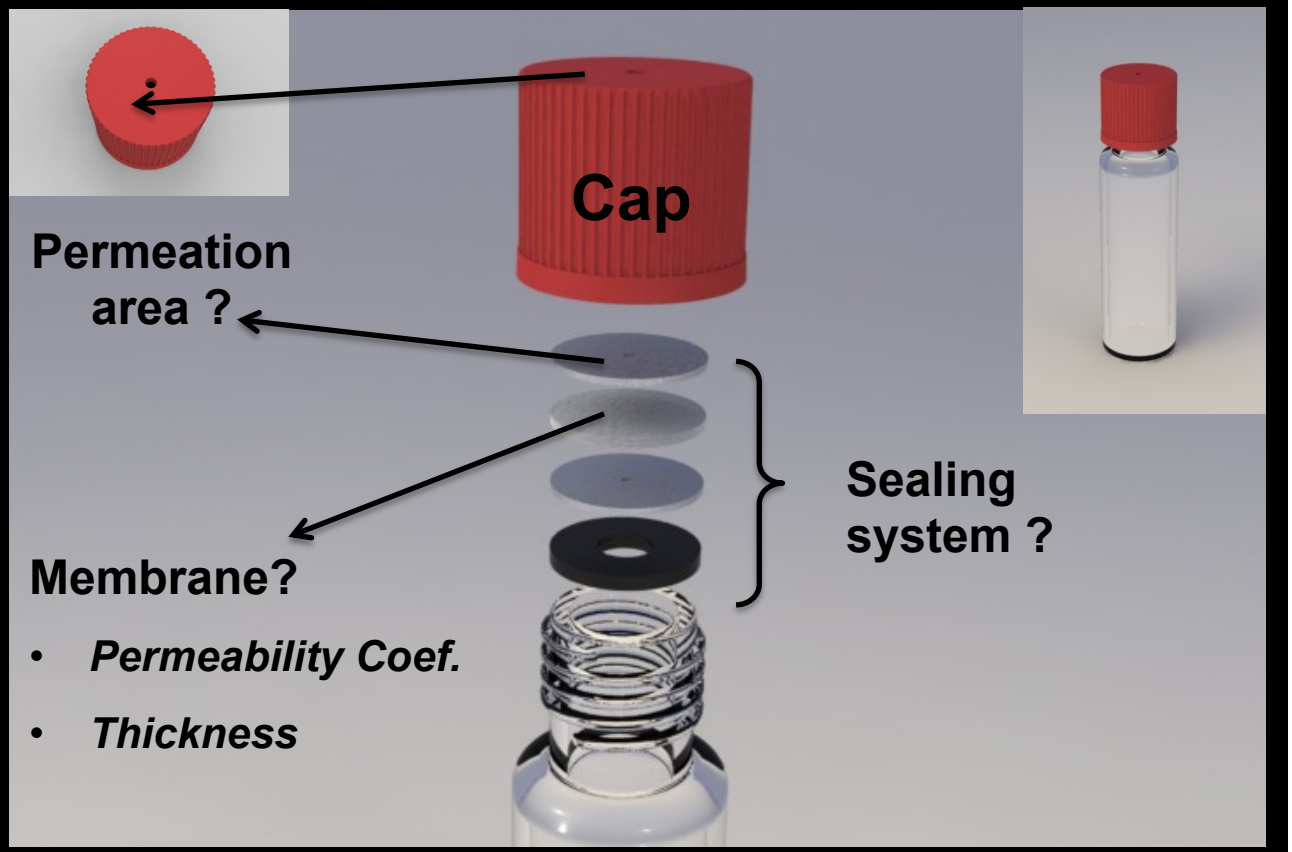
Q - Leak Flow rate

Pe – Permeability coefficient

A – Permeation Area

d – Membrane Thickness

Δp – Pressure difference



Q units: mbar.l/s; g/year; cm^3/s; Torr.l/s; $Pa.m^3/s$.....

Goal: Q = 5g/year

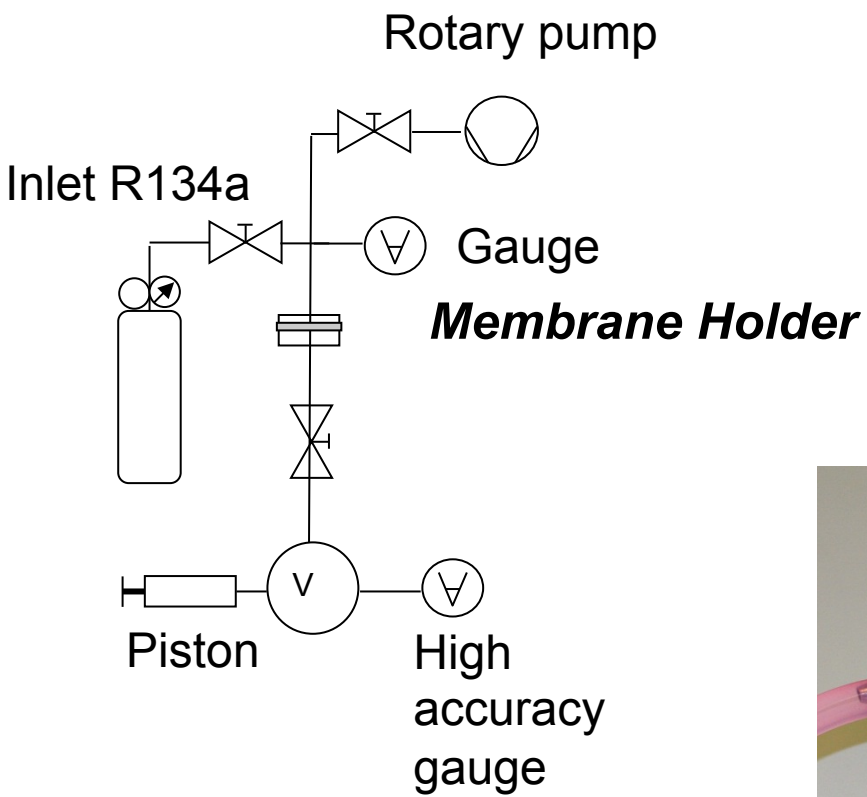
Membrane characterization

It was necessary to select a permeation membrane suitable for this propose.

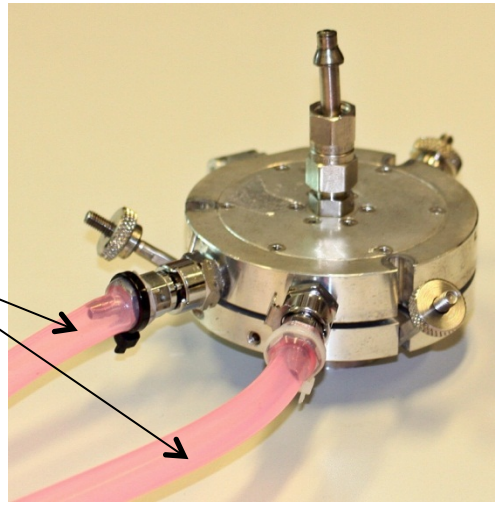
- Arlon Silicone
- Neoprene
- Polyurethane
- ….
- MVQ Silicone
  - 0,5mm thickness
  - 1mm thickness

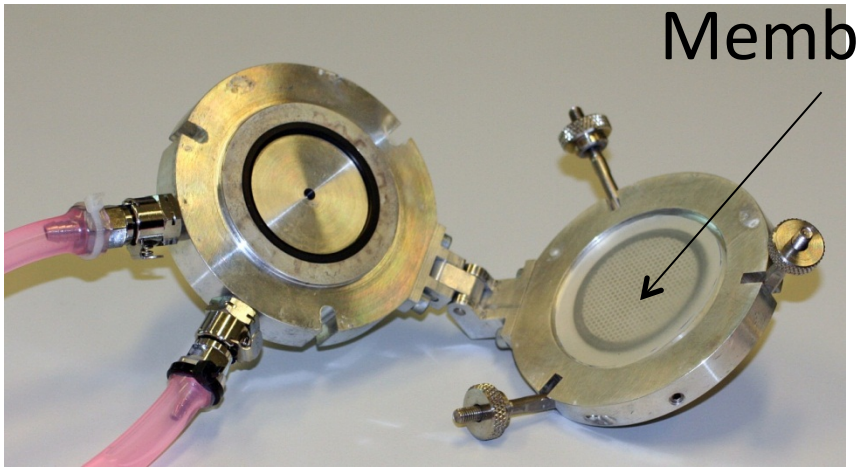
After some considerations and preliminary tests MVQ Silicone.

Experimental procedure for measuring the membrane permeability coefficient

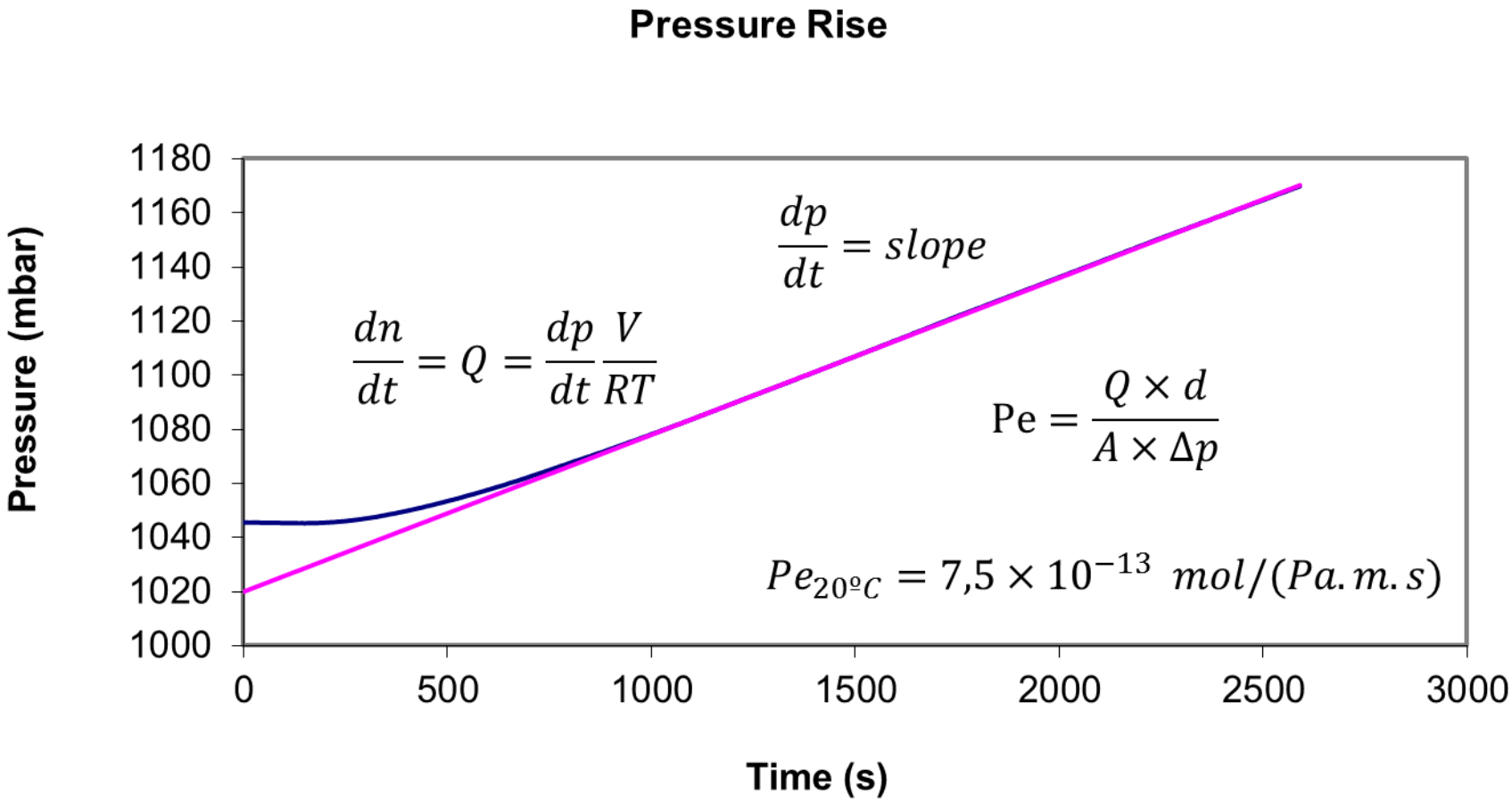


Control bath temperature





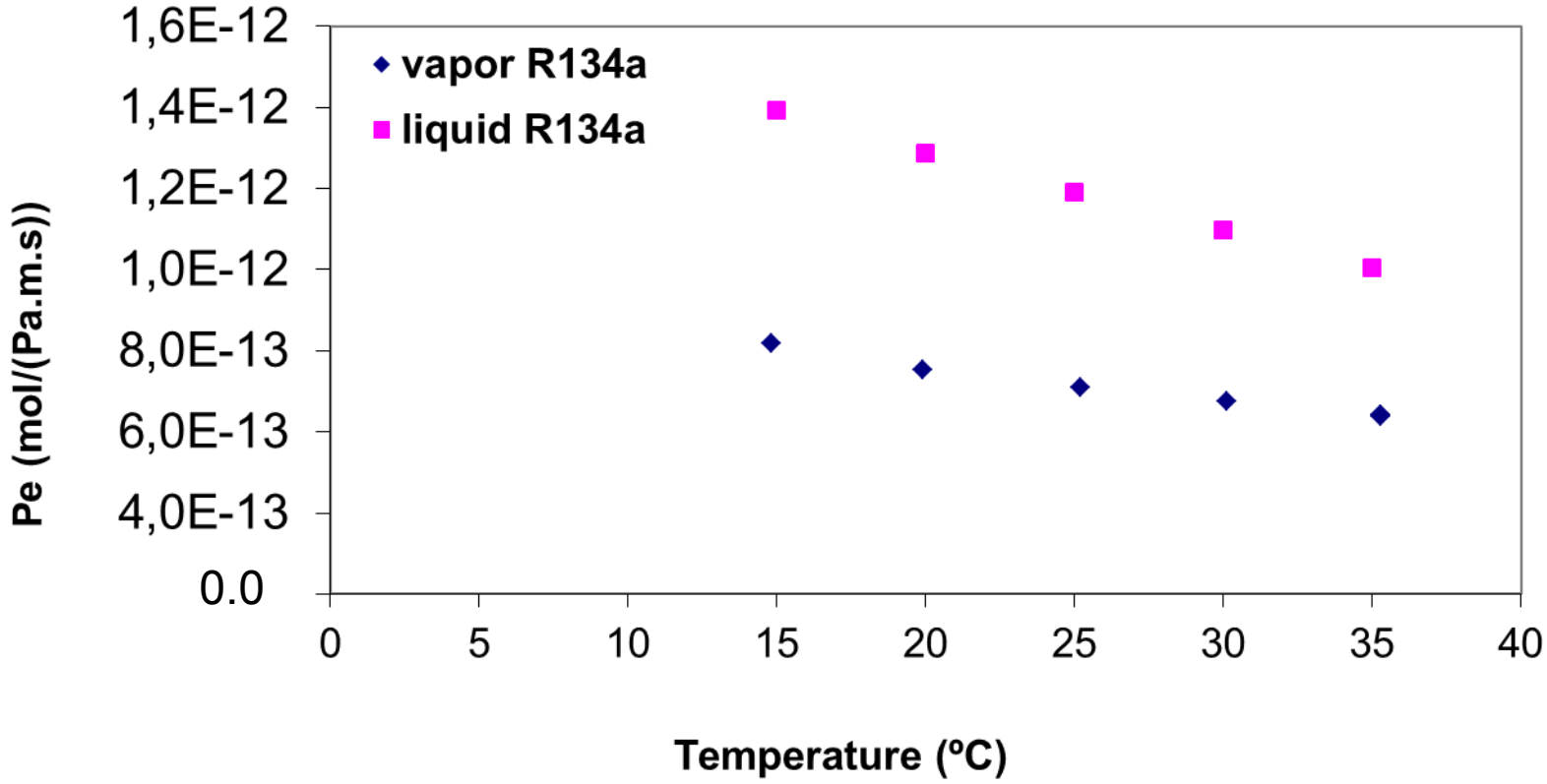
Membrane permeability coefficient determination



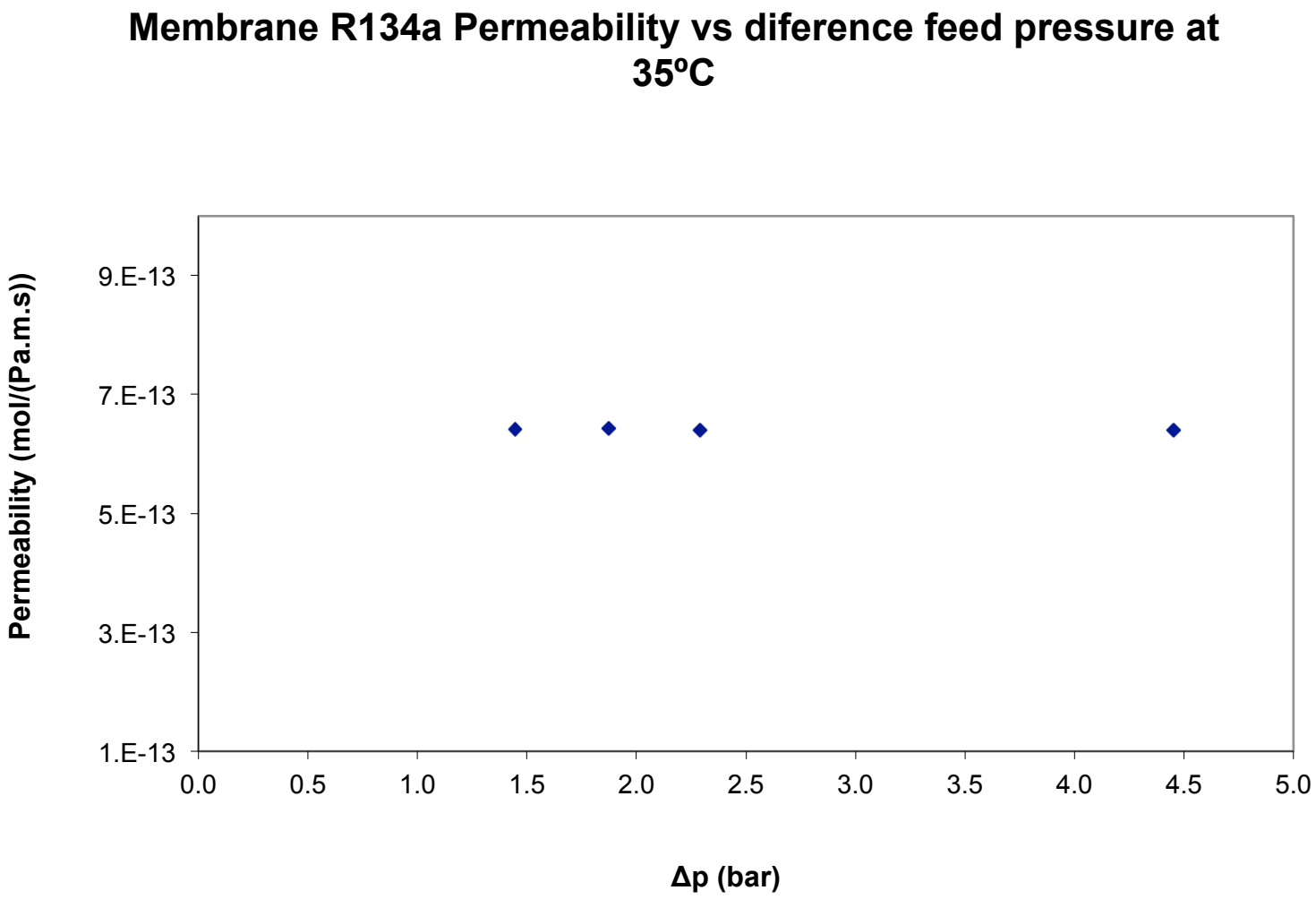
Membrane characterization

- R134a Liquid and vapor
  - Leak at vertical
  - Leak at horizontal
- Different Feeding Pressure
- Different Temperature Test

Membrane characterization



Membrane characterization



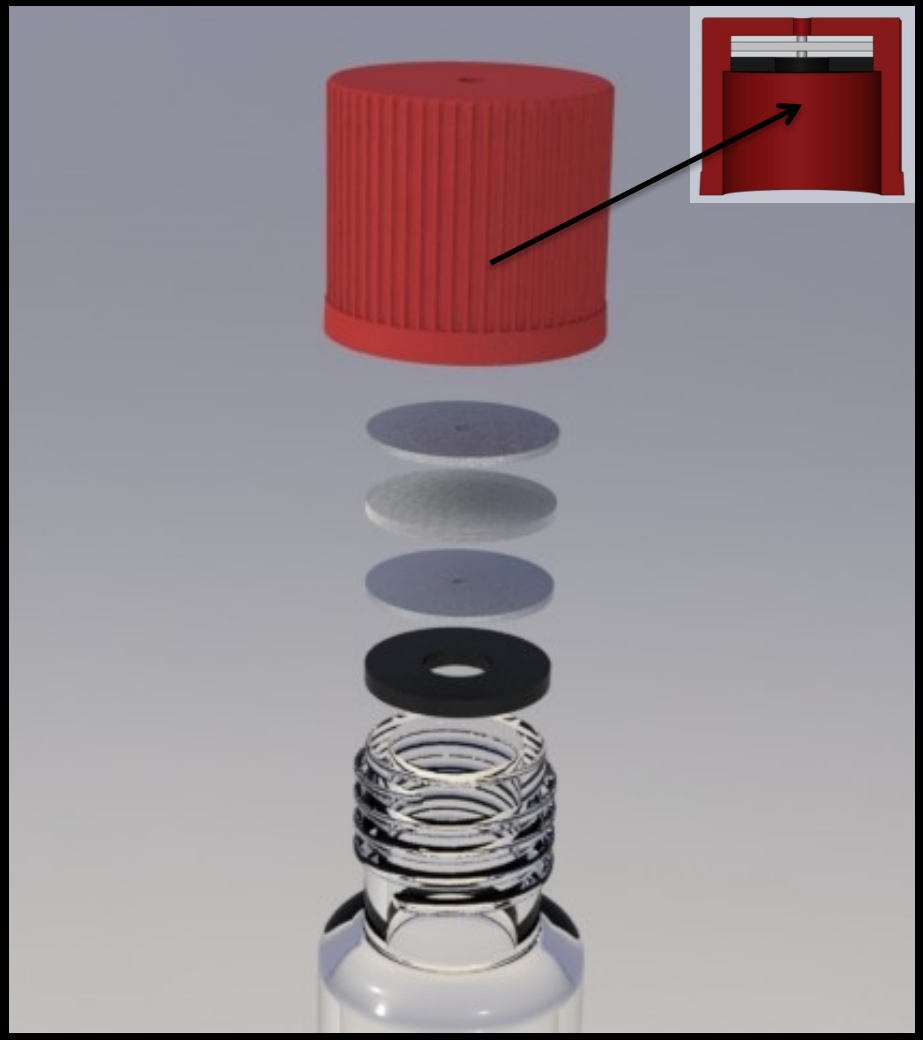
Leaks vials characterization

- Reinforced Pyrex glass vials
- 20ml capacity
- Screw cap
- MVQ membrane, 1mm thickness

(Pe (20ºC) = 7,5E-13 mol((Pa.m.s))

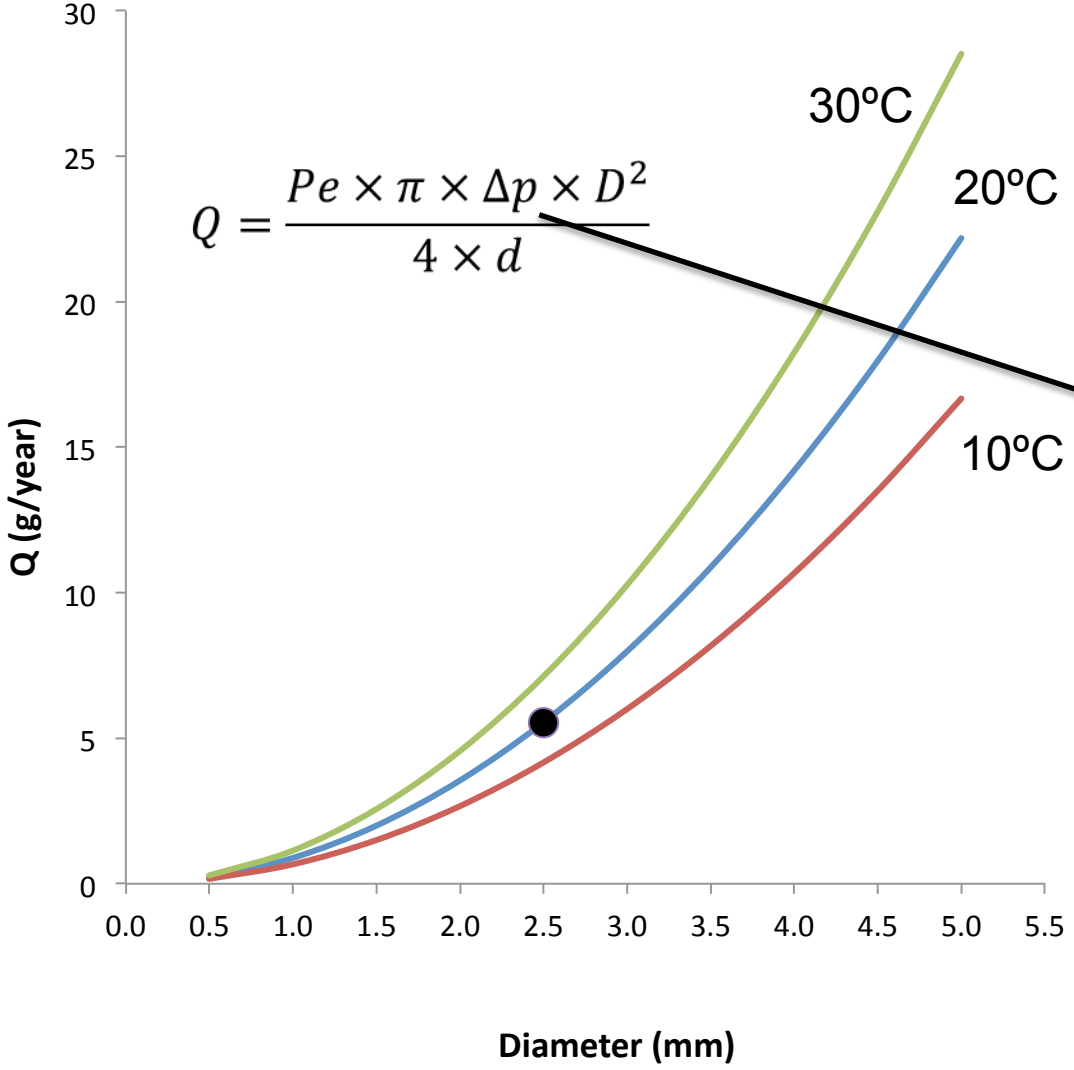
- 2 aluminum washers
- 1 neoprene washer

diameter hole?

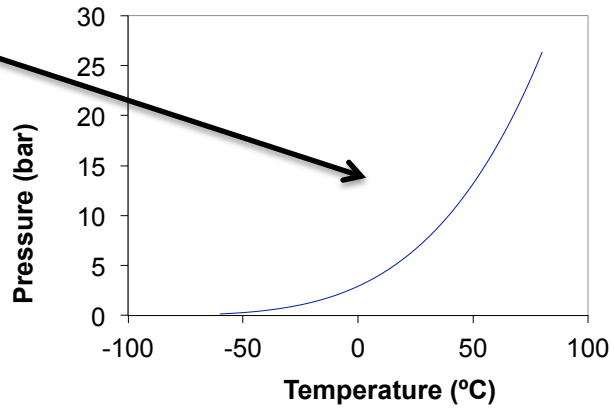


Diameter hole

$$Q = \frac{Pe \times \pi \times \Delta p \times D^2}{4 \times d}$$



R134a Pressure vs Temperature

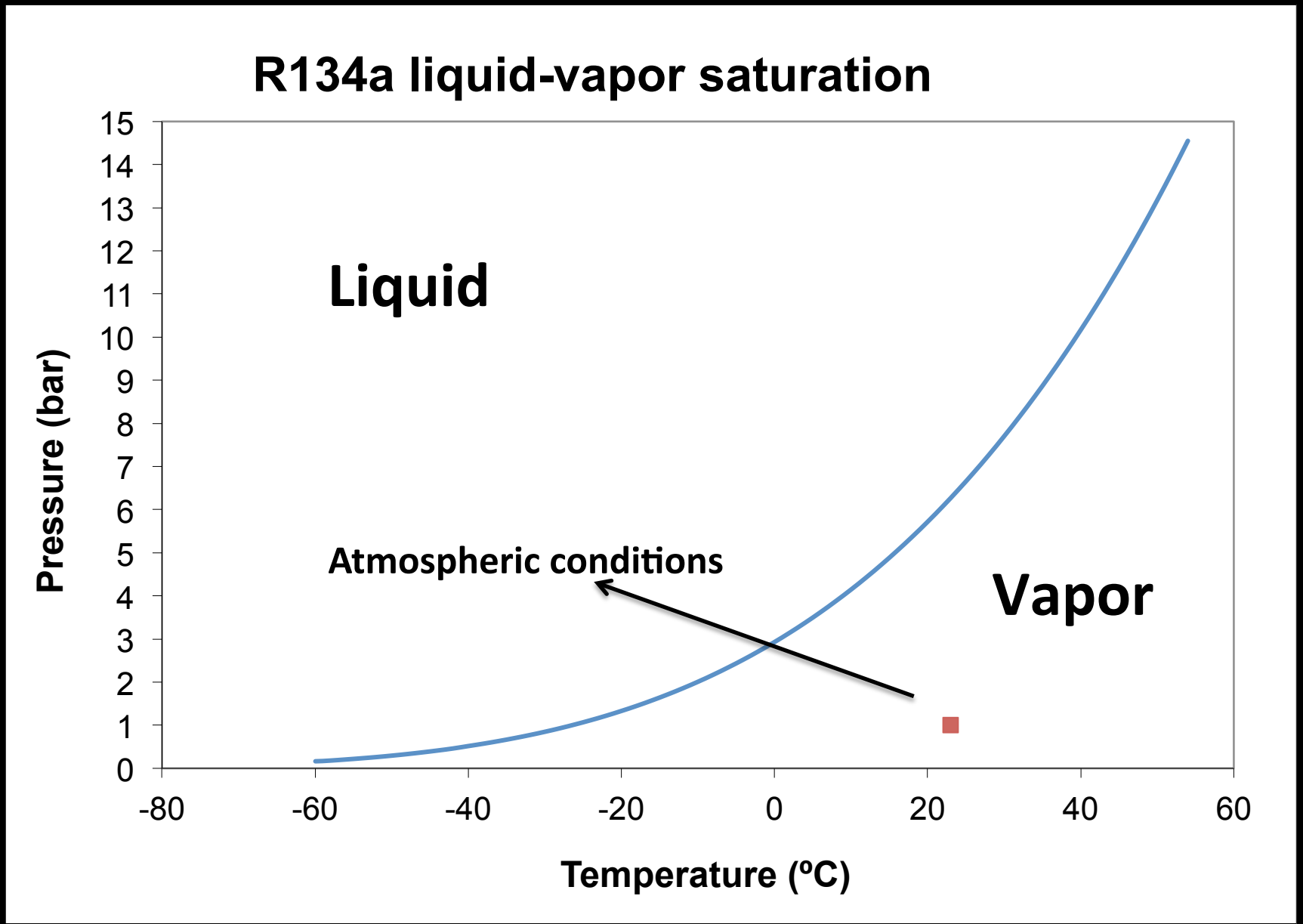


1. Specifications of the components and characterization of the leaks

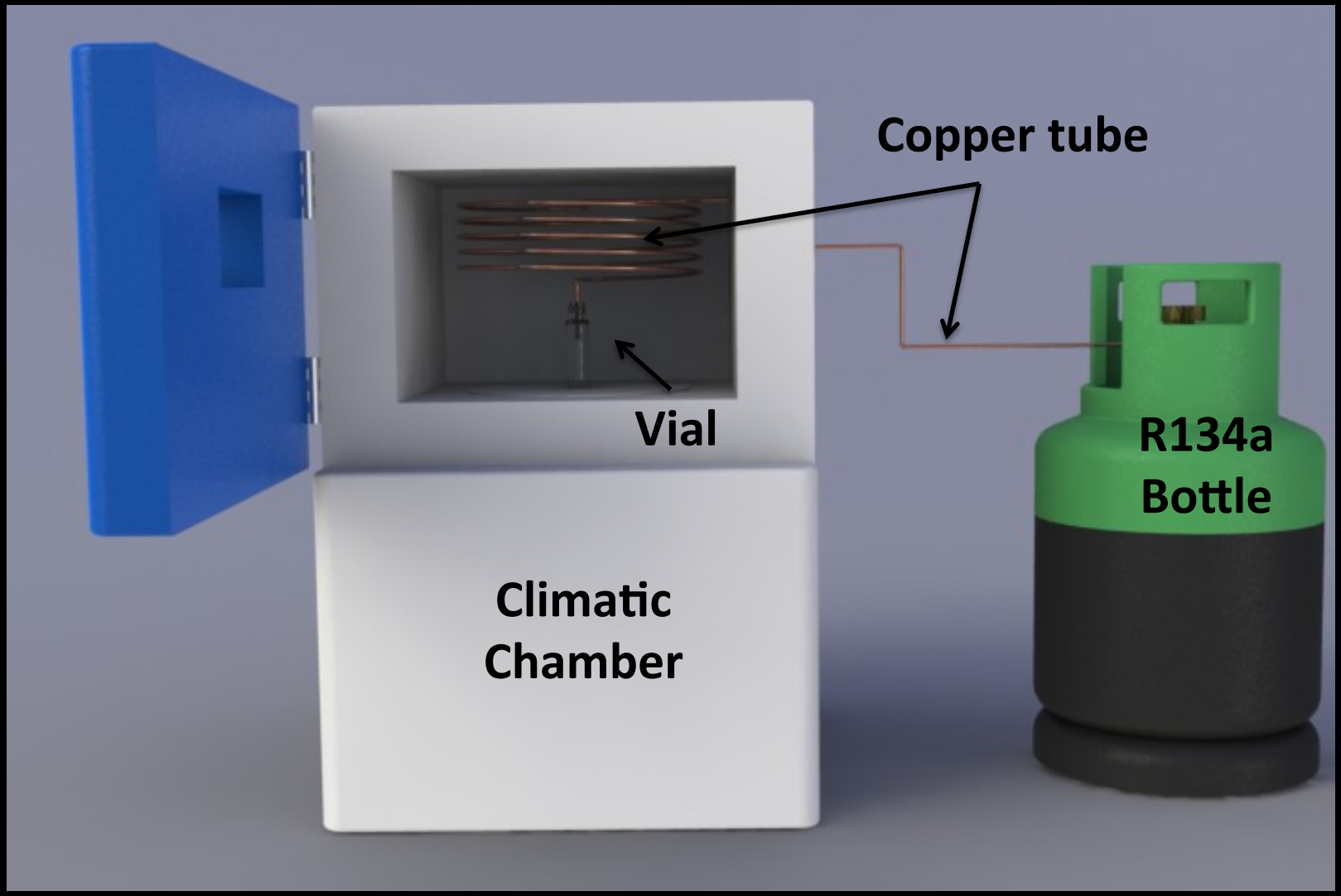
2. *Filling the vials*

3. Verify their leak rate

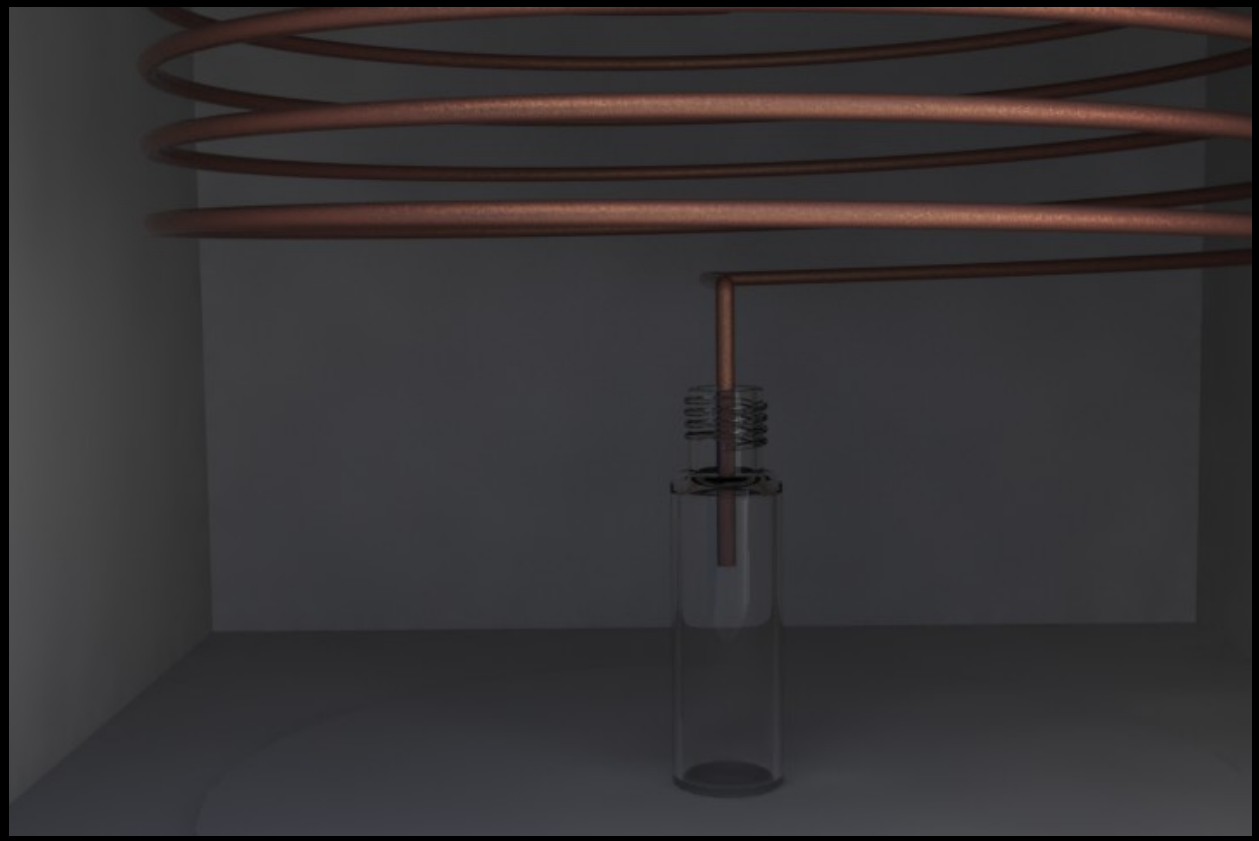
Filling the vials



Filling the vials



Filling the vials



•The reservoirs are filled at a temperature of -30ºC in a climatic chamber.

•The refrigerant gas flows in a long copper tube with 1 mm diameter from a R134a bottle placed outside the chamber.

- Therefore the vials are easily filled with liquid refrigerant and closed before start warming.

1. Specifications of the components and characterization of the leaks

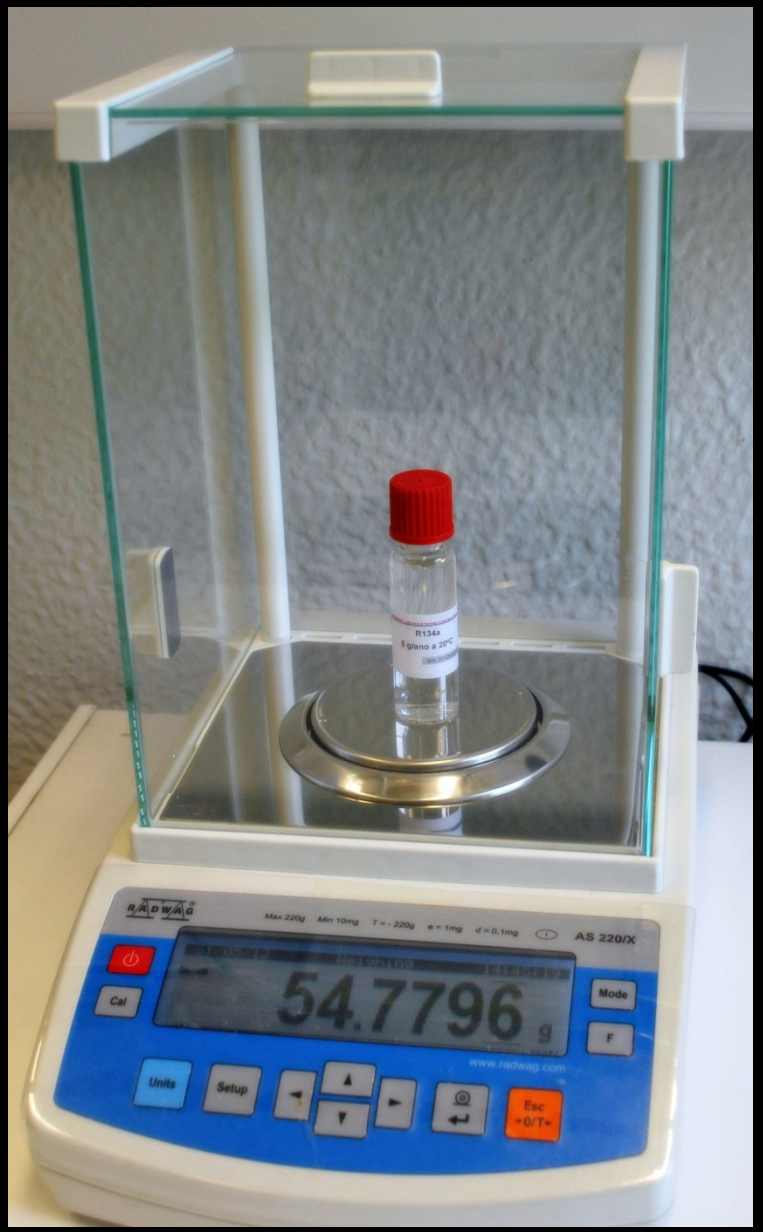
2. Filling the vials

3. *Verify their leak rate*

Now that the vials are filled with R134a, how to measure their leak rate?

↓

GRAVIMETRIC METHOD



Gravimetric method

Weight the vial before and after a suitable time period

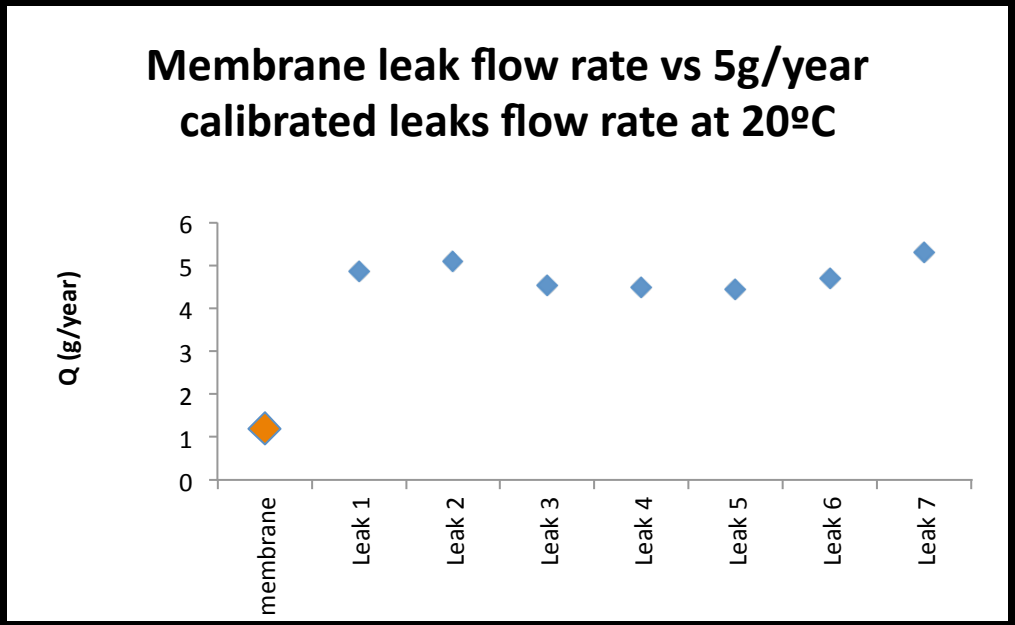
The leak rate can be calculated from the weight loss

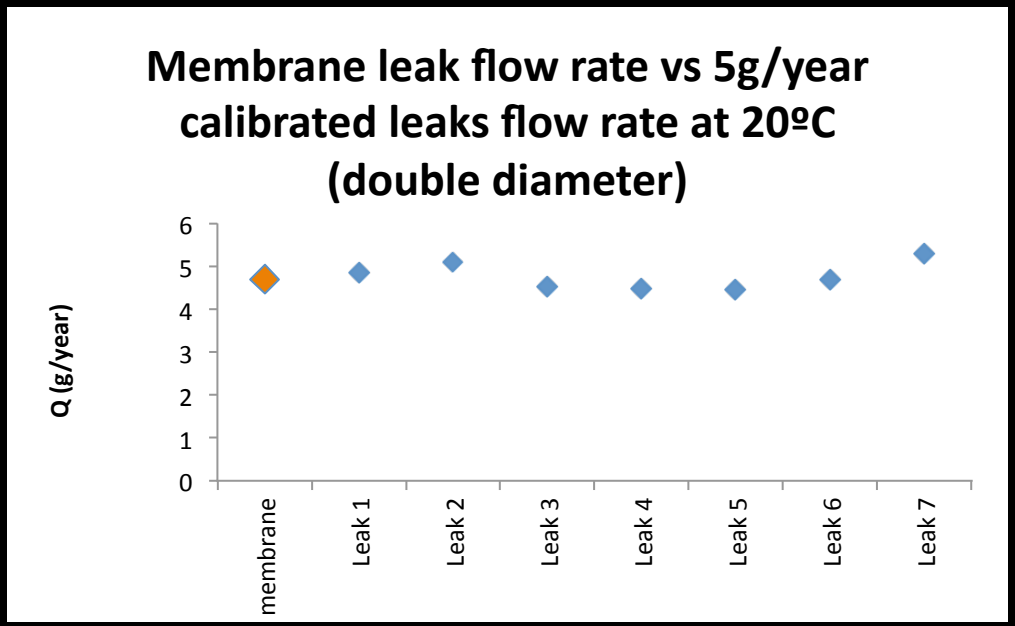
Disadvantage: Since the weight loss per unit time is rather slow, this approach needs long time periods for the measurement.

$$Q = \frac{dm}{dt}\left(\frac{\mathrm{g}}{\mathrm{year}}\right)$$

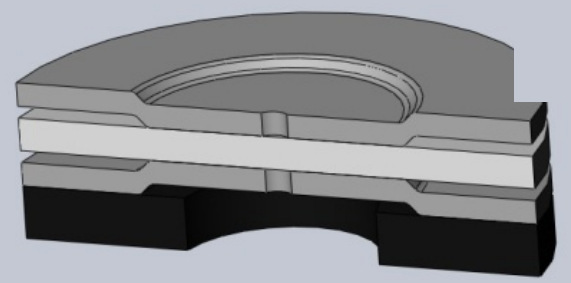
Leak flow rate Q

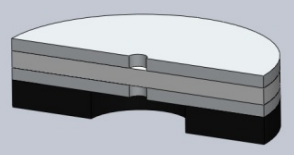
Is the Q obtained with the membrane characterization similar to the one obtained with the Leaks?

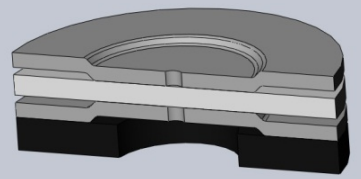




- The Q obtained with the calibrated leaks is higher then the obtained with the membrane characterization.
- If the diameter of the hole used to define the area of permeation increase to the double, Q would be the expected.
- The permeation area was not the correct one , so the sealing part need some small modifications







With this alterations the permeation area was better established and the leak rate obtained was closed to the desired.

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Thank you for your attention!

Questions?