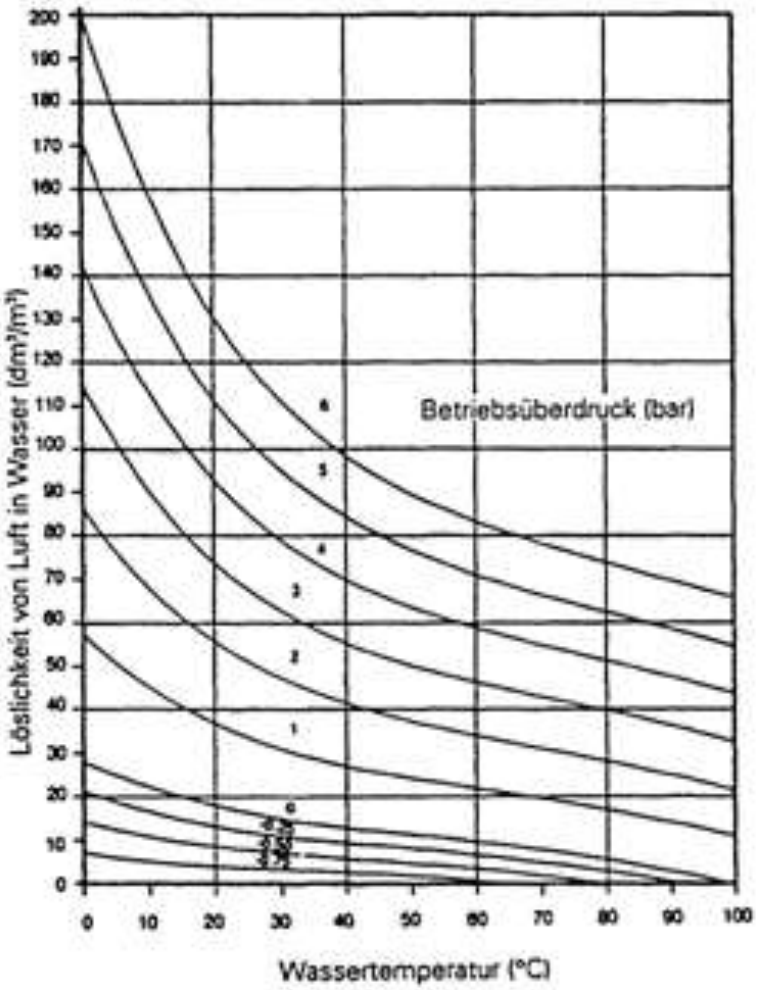
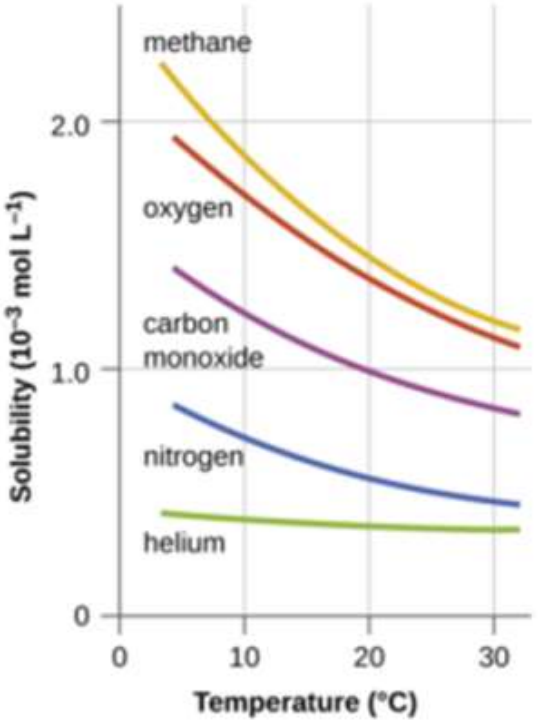
Mechanisms of oxygen entry in heating systems

resus

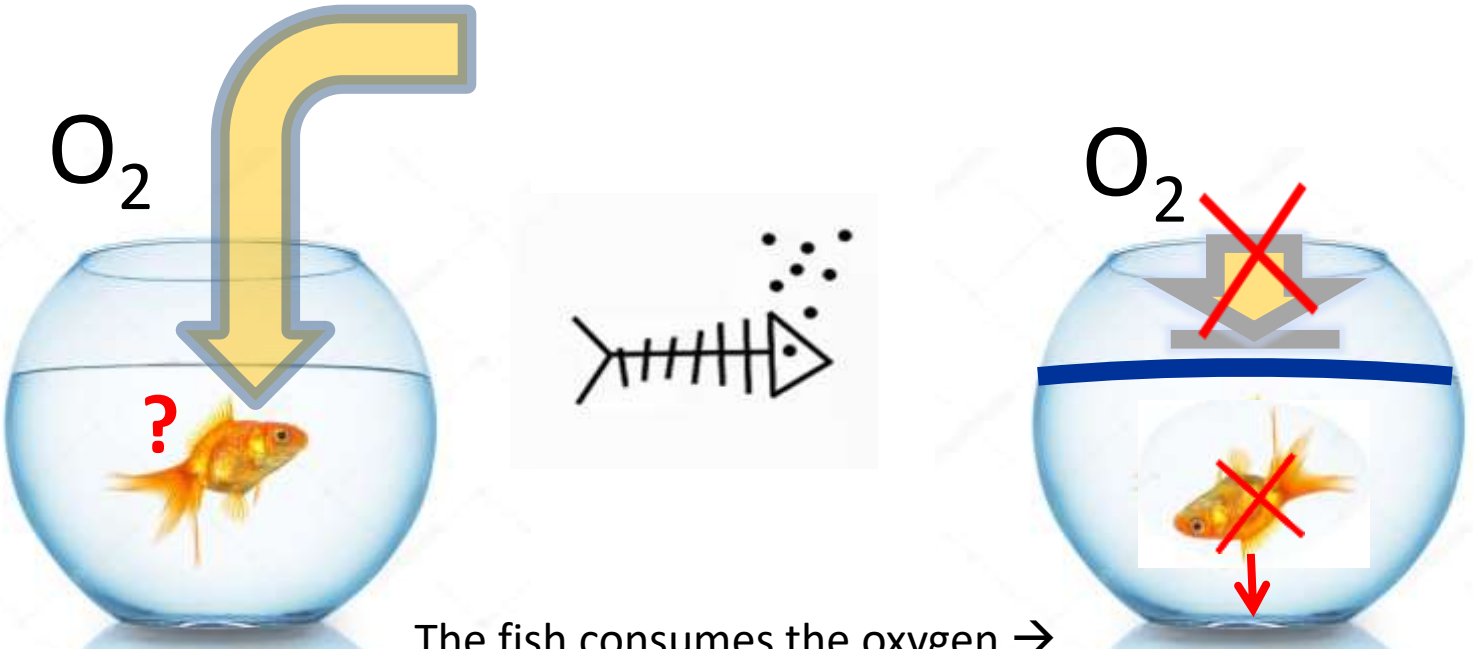
Heating systems want to absorb oxygen to restore a natural balance:

(Henry's Law / inbalance in partial pressure)





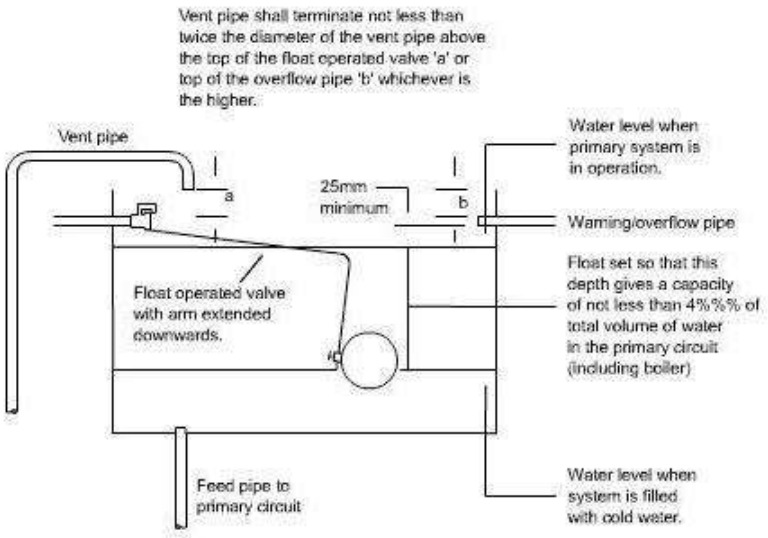
Corrosion prevention = eliminate oxygen ingress



The fish consumes the oxygen →
partial pressure becomes lower than normal →
absorption process of fresh oxygen from the atmosphere→

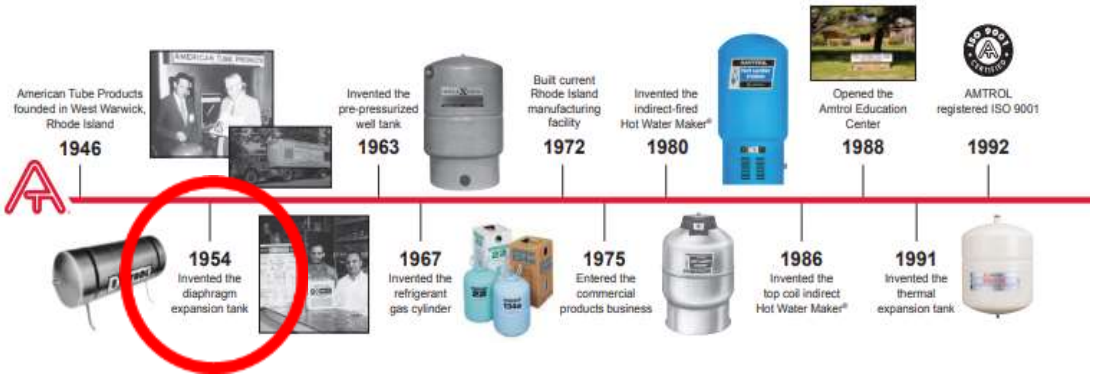
The more the oxygen gets consumed →
increase of difference in partial pressure →
the more fresh oxygen goes in→

open expansion tank = permanent oxygen entry

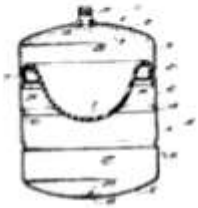


- PRO:
  - Simple, cheap, easy to install
  - Lowest possible, constant pressure, no pressure increase
  - Automatic degassing when hot
- CONTRA:
  - Evaporation when hot, energy loss
  - Oxygen absorption when not hot > corrosion sludge > PROBLEMS
  - Reduced longevity, blockages because of sludge generator

That's why Chester H. Kirk in the U.S. invented the sealed expansion tank in 1954 and filed patent in 1959



3,035,614
EXPANSION TANK
Chester H. Kirk, Jr., 14 Glen Ave., Cranston, R.I.
Filed Nov. 4, 1959, Ser. No. 850,872
6 Claims. (Cl. 138—30)



1. An expansion tank comprising a hollow body member having a side and end walls, a flexible diaphragm in and spanning said body member between said end walls and having a peripheral portion in peripheral engagement with said side, a continuous ring having a groove in its outer periphery engaging and receiving said peripheral portion and an inwardly extending peripheral rib in said side engaging said peripheral portion of said diaphragm and compressing it into said groove to secure said ring and diaphragm against movement and seal said diaphragm to said side.

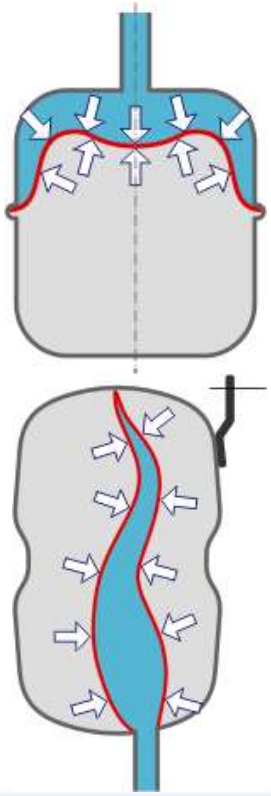
Thermal expansion is absorbed by a permanent (compressible) gas cushion, separated from the water by a rubber membrane

Maybe the first one was Swiss Carl Stücklin in 1958, using the air chamber (PNEU) of a truck tyre, creating the first PNEUMATEX?

Flamco claims it was their MD, Johan Wormmeester, who had the idea of clenching two cooking pots together with a metal clenching ring and having a rubber “bowl hat” in between the two parts

Sealed system: sealed membrane expansion tanks

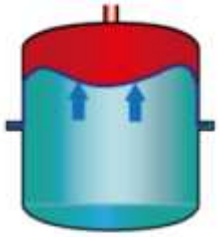
Membrane or bladder type



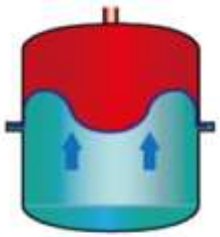
- PRO
  - Near to (or inside) the boiler
  - Lower installation cost (proximity)
- CONTRA
  - Variable pressure
  - Diffusion of the gas cushion through the membrane > after some time WORSE than open system:
    - AIR INGRESS through AAVents
    - Reduced longevity for the entire system
  - Several other complications (opening pressure, membrane stretch, residual water)

Consequences of variable pressure

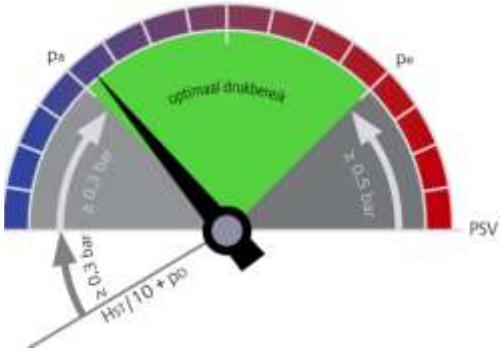
Toestand bij levering
(voordruk)



Installatie gevuld
geen opwarming
(vuldruk)



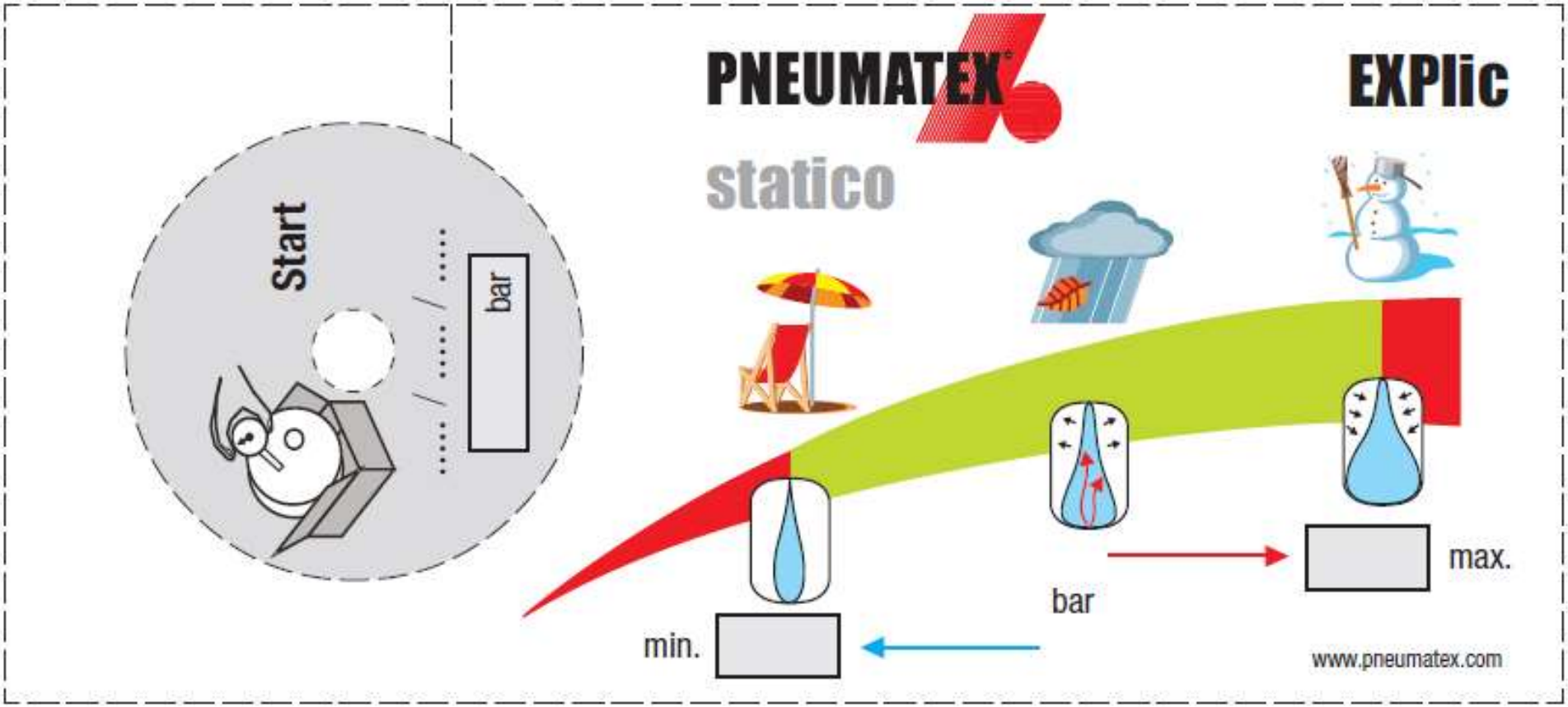
Maximum druk bij de
hoogste temperatuur
(einddruk)



Compression of the gas cushion leads to pressure increase (BOYLE's law)

- Consequently substantial difference between gross volume vs. useful volume
- Users don't relate the pressure increase vs water absorption of the tank: daily practice shows numerous problems
- Problem cost can be extreme: multiple of cost of the tank

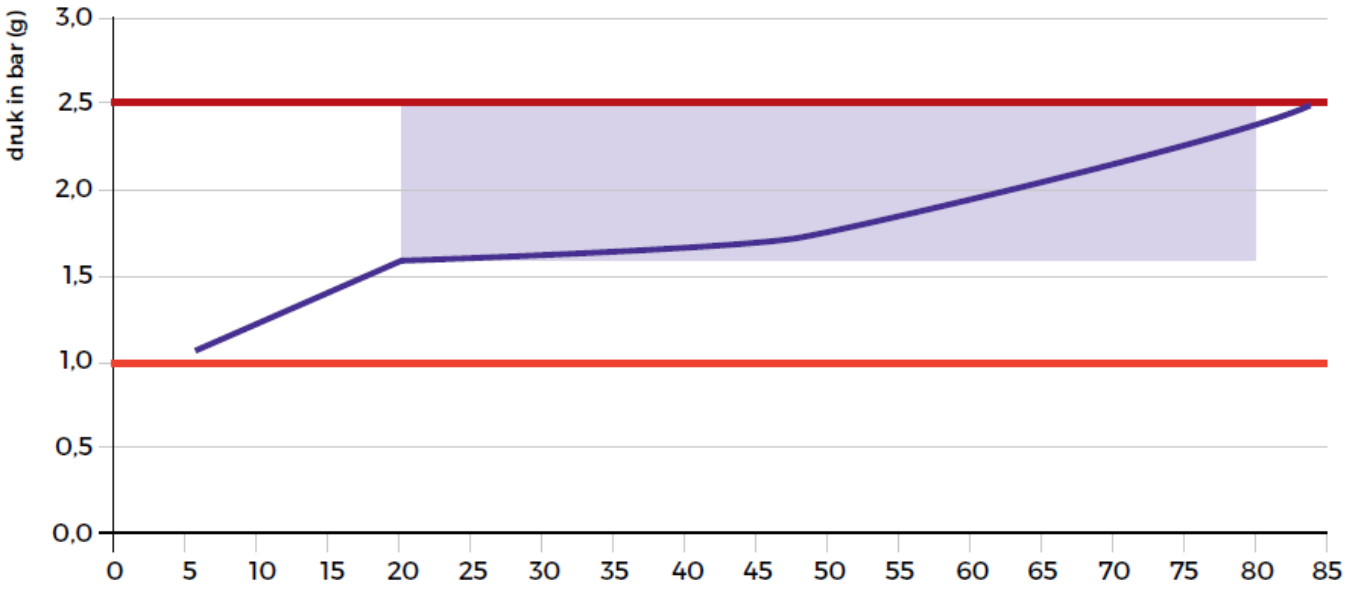
Reality however shows that:
systems with closed expansion tanks
(variable pressure) BARELY VARY IN PRESSURE



HOW COME? … and what are the consequences ?

T-P graph in theory

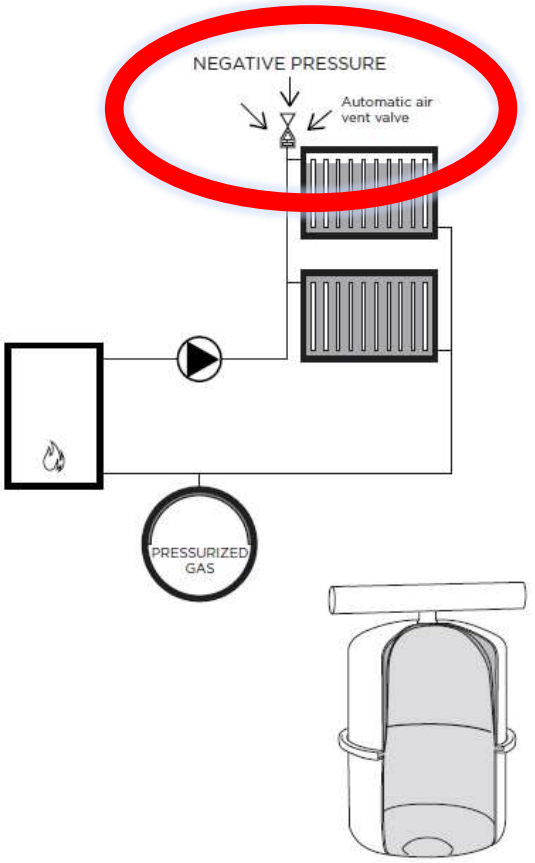
Figuur 2:
T-P GRAFIEK VOOR WARMWATERINSTALLATIES



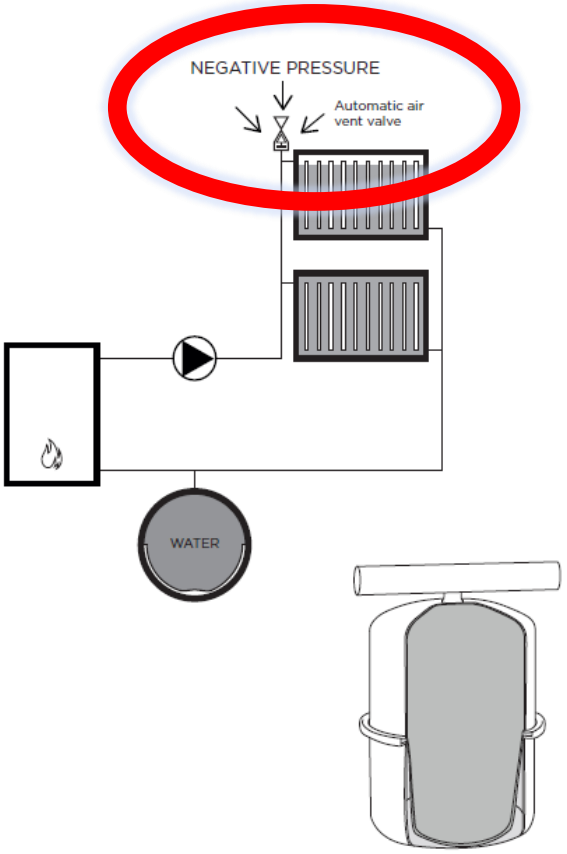
- de gewenste druk bij een gegeven temperatuur
- absoluut minimale druk (= voordruk expansievat)
- absoluut maximale druk (= openingsdruk veiligheidsventiel minus veiligheidsmarge). De veiligheidsmarge = 0,5 bar bij ventielen tot 3 bar, 10% bij hogere insteldrukken
- de drukvariatie weer die in warmwatersysteem mag heersen (verticaal druk in bar(g), en horizontaal temperatuur in °C). Het veilige gebied (geen onmiddellijk risico op onderdruk of overdruk) is in feite een band over en onder de blauwe lijn.

If pressure at the highest point is not guaranteed AT ALL TIME, there is an even more serious problem

Excessively high inflation pressure, therefore, too little water in the expansion vessel



Inflation pressure too low (potentially due to loss of inflation pressure?), therefore too much water in the expansion vessel



Known mechanisms of oxygen entry:
Magnetite formation [g] in a 1000l water system:

Cause of oxygen entry	Once (startup)	Yearly	Ranking
Residual (trapped) AIR 10%	91		6
Initial FILL water	36		7
Topping up (replenishment)		3,6	8
Negative pressure		**3.658**	**3**
Permeation through plastics with EVOH layer		135	4
Permeation plastics no oxygen barrier		***235.686***	***1***
Permeation rubber hoses		**5.971**	**2**
Oxygen from expansion tank 150/1,5	375		5

Conclusion: proper system design

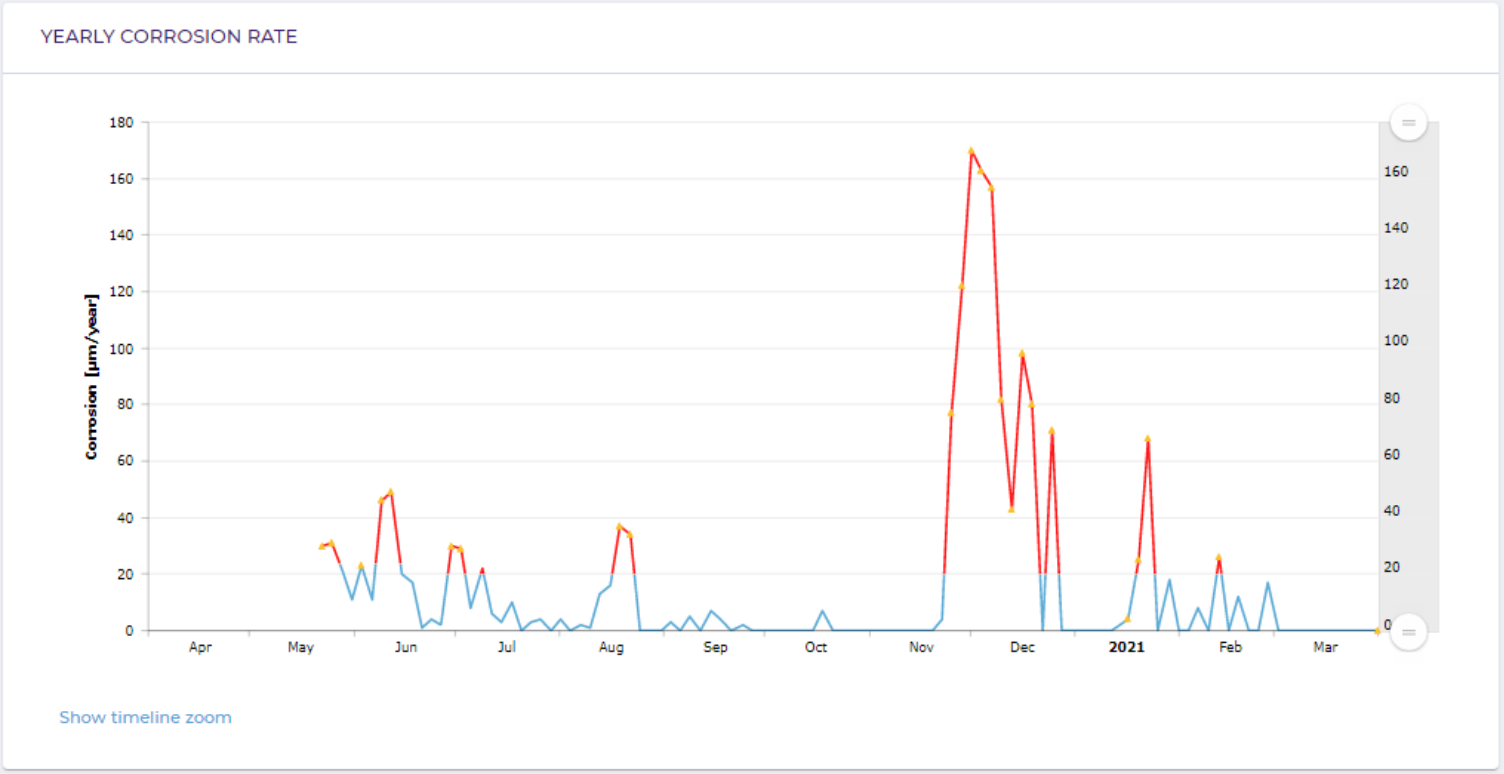
- Do not use oxygen diffuse synthetics
  - “old” (non-barrier type) polyethylene, polybutene, polypropylene, PVC, …
  - Rubber
- Take care of proper pressurization
- Minimize other risks
- Protect by means of corrosion monitoring

Minimize other risks: Domestic hot water preparation

Safety valves that (often) leak ALWAYS reveal an underlying problem

Other risks: Domestic hot water preparation

- Safety valves that (often) leak ALWAYS reveal an underlying problem: case PIVA



Other risks: Domestic hot water preparation

Safety valves that (often) leak ALWAYS reveal an underlying problem: case PIVA

Other risks:
Domestic hot water preparation

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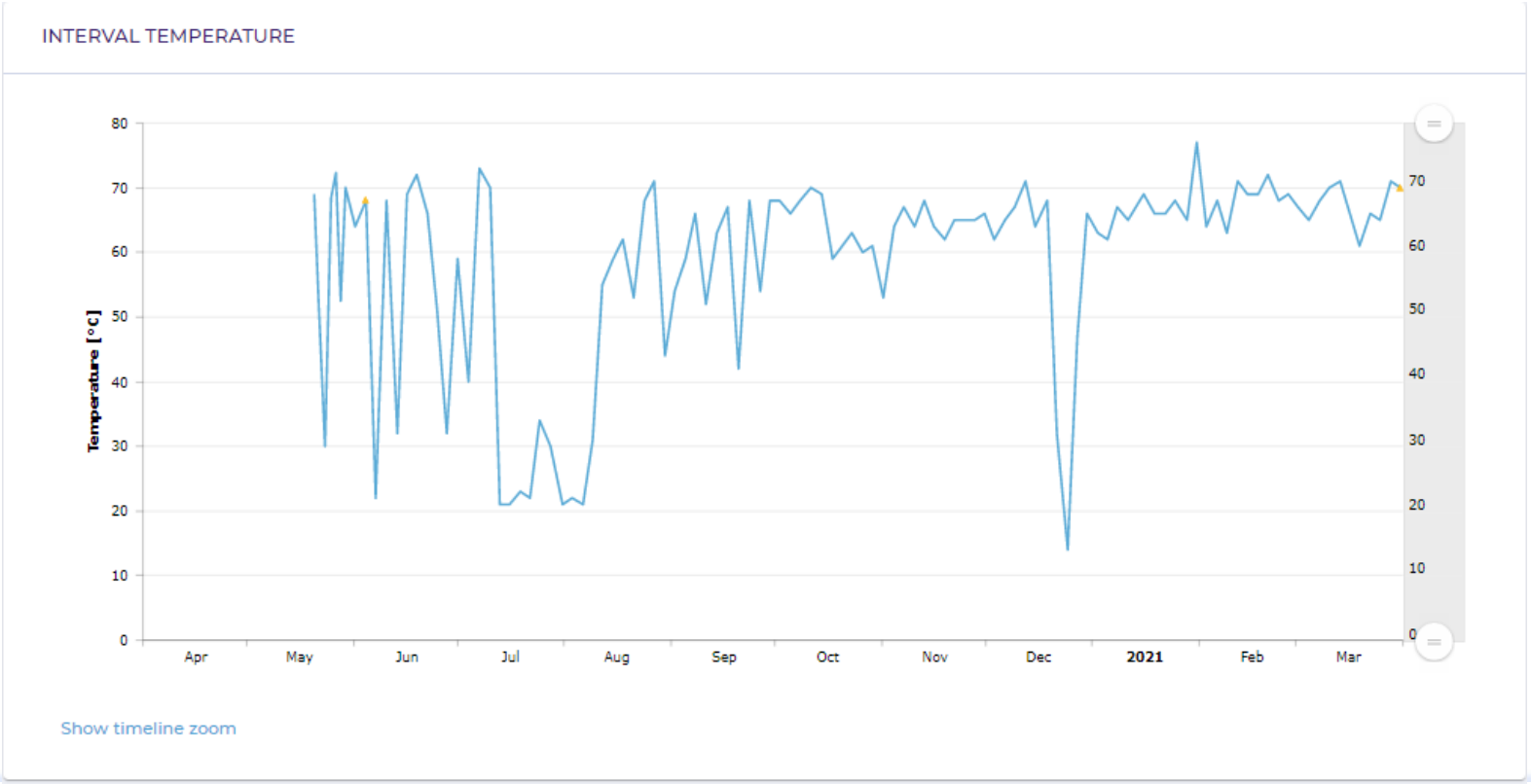
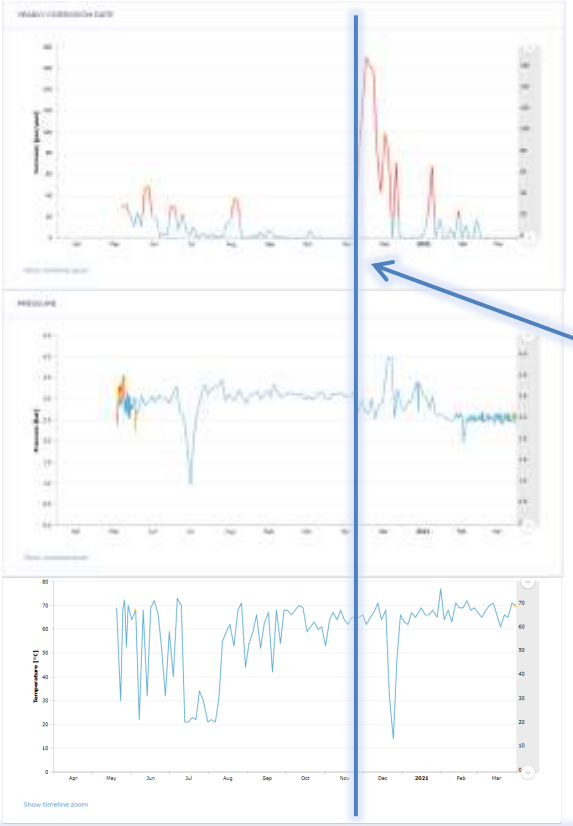
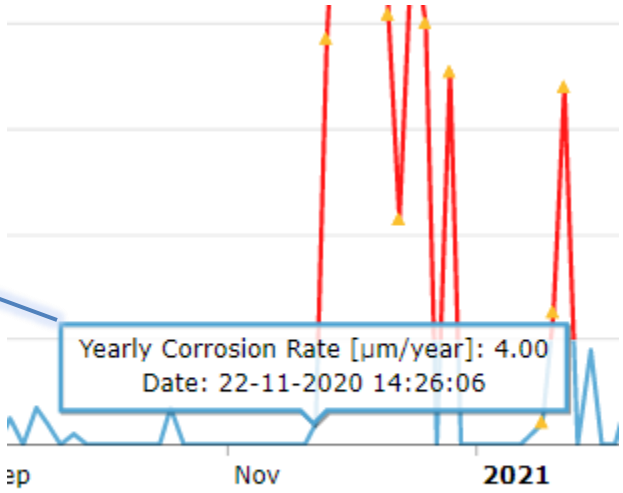


Other risks:
Domestic hot water preparation

Safety valves that (often) leak ALWAYS reveal an underlying problem: case PIVA

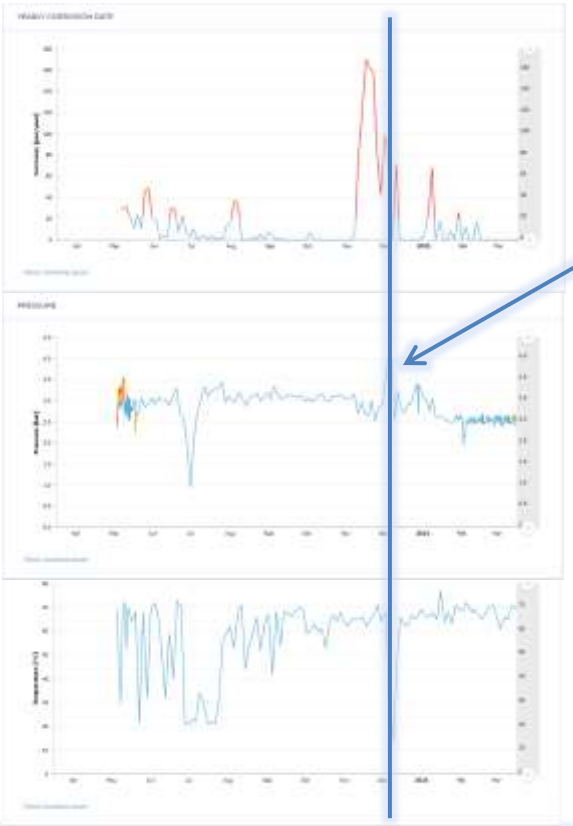


Start of a heavy increase in corrosion rate



Other risks:
Domestic hot water preparation

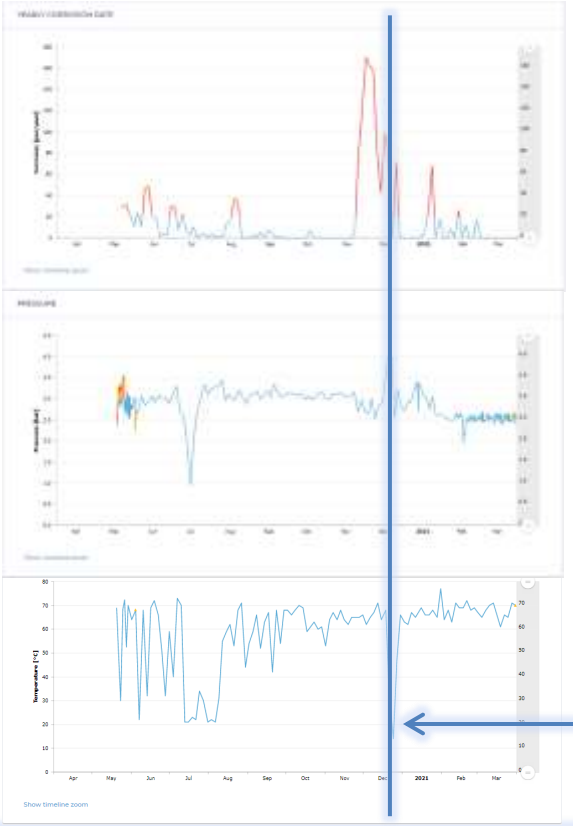
Safety valves that (often) leak ALWAYS reveal an underlying problem: case PIVA



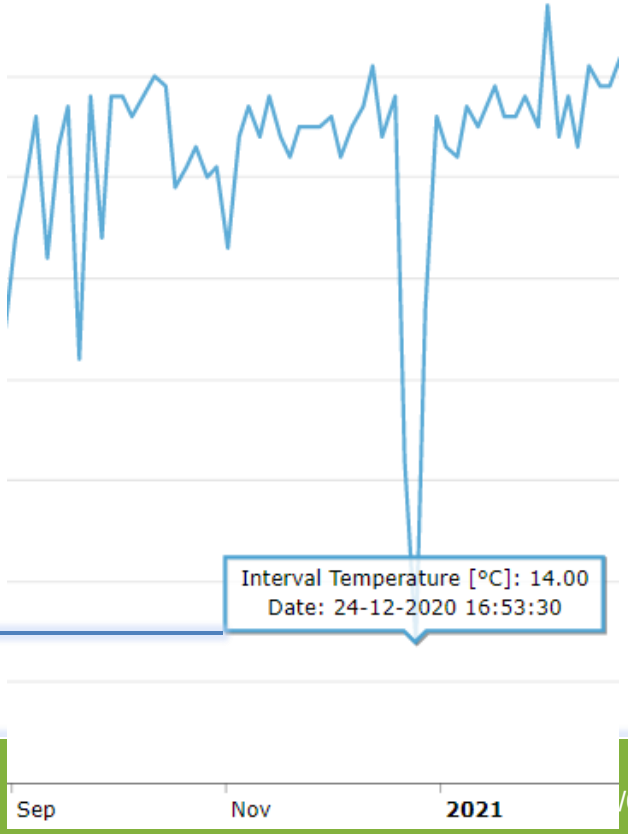
First opening of safety valves at 4 bar

Other risks: Domestic hot water preparation

Safety valves that (often) leak ALWAYS reveal an underlying problem: case PIVA



System breaks down, temperatures drop to lowest level



We encounter one such system at least once a month…

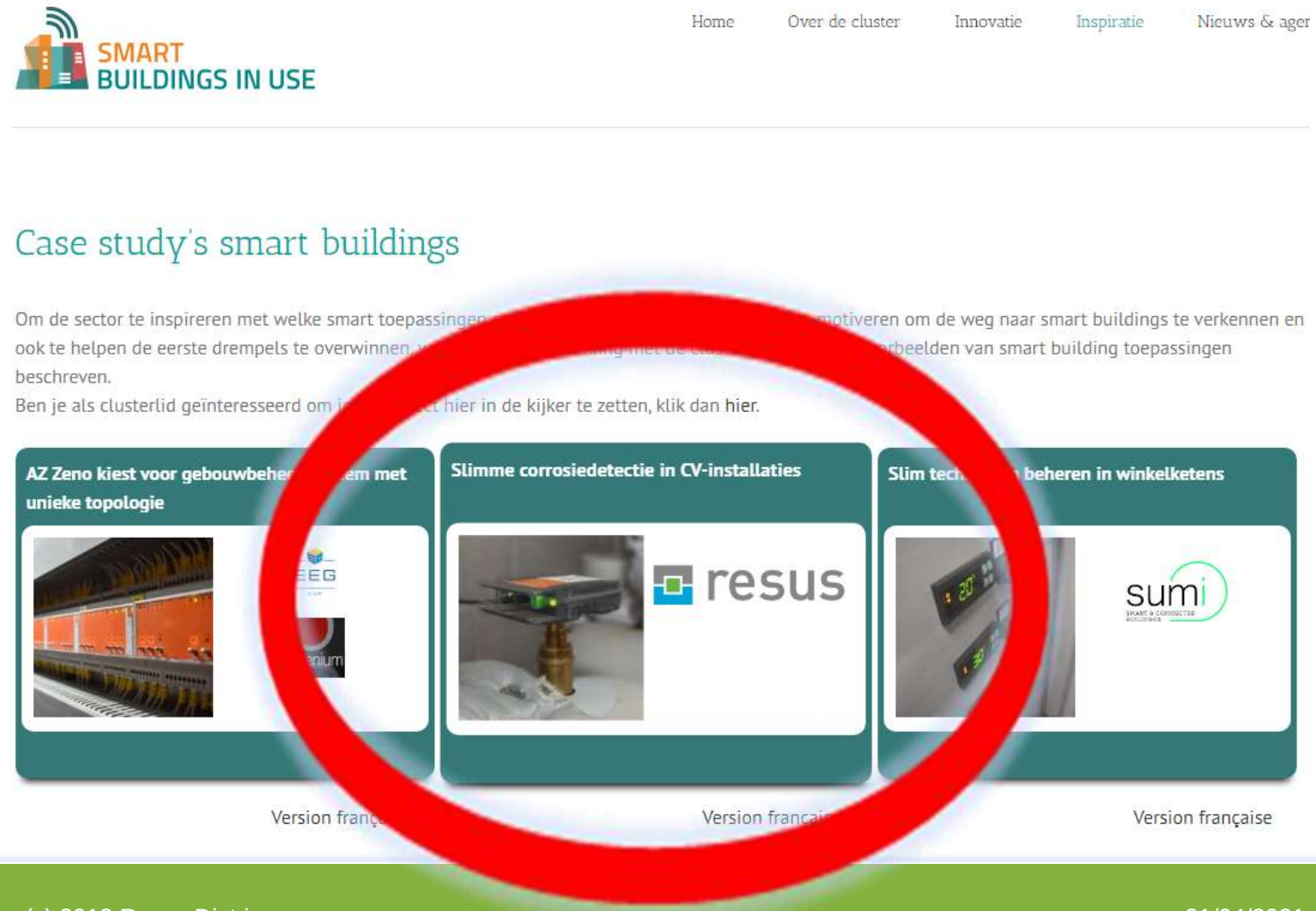
- Cause can be a leaking boiler or plate heat exchanger
- Or a combination with other causes, which is the reason that the true underlying cause is masked by other symptoms (see further)
- The user very seldom sees the problem
  - His heating system works fine most of the time
  - Leaking safety valves are often connected to drain pipes
  - The awareness of the long-term consequences is just not there

Just a few examples

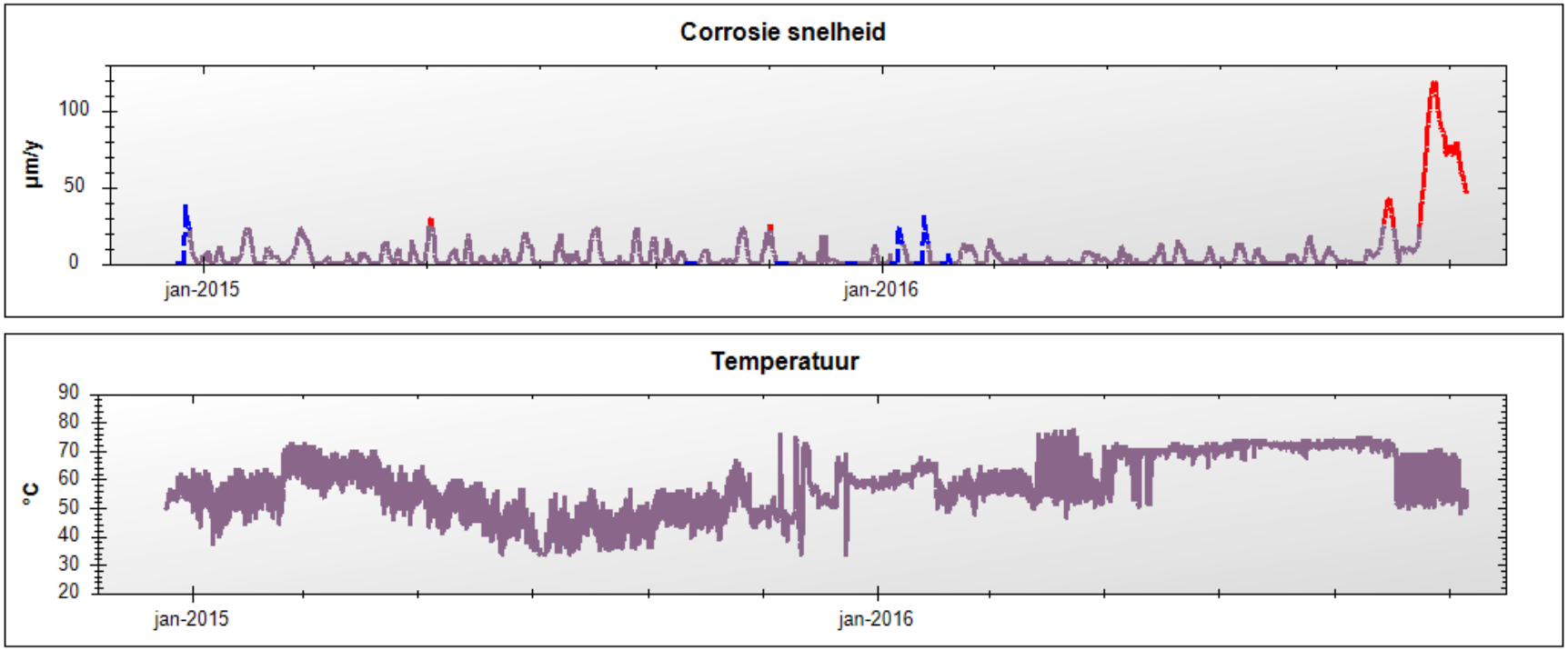
VERY OFTEN leaking safety valves may also reveal a defunct expansion / pressurization

- Loss of inflating pressure
- Wrongly situated zero-point
- Malfunctioning content indicator
- Pressurization tank (system) undersized or wrongly calibrated

Minimize other risks:
pressure step degasser (vacuum degasser)

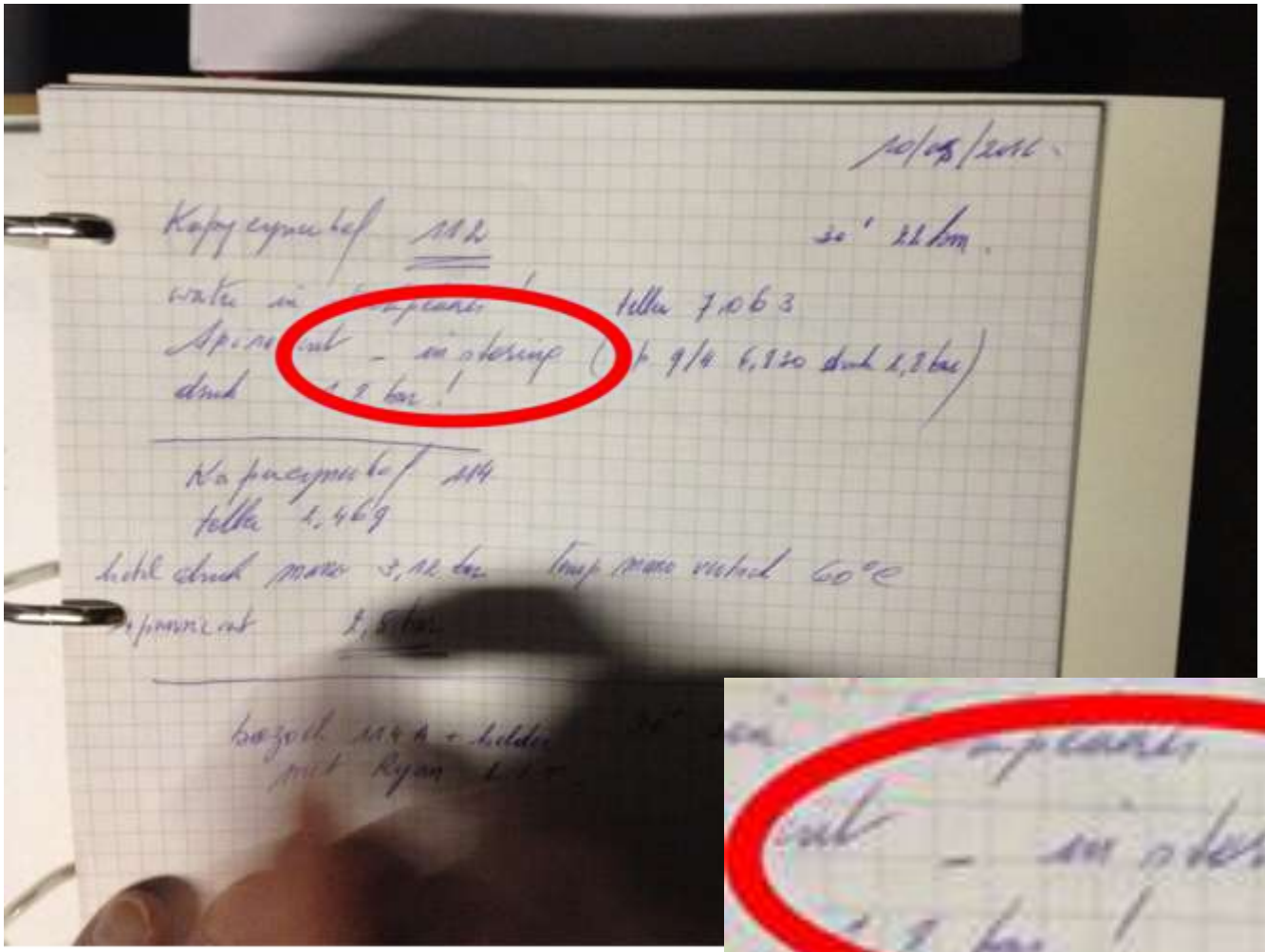


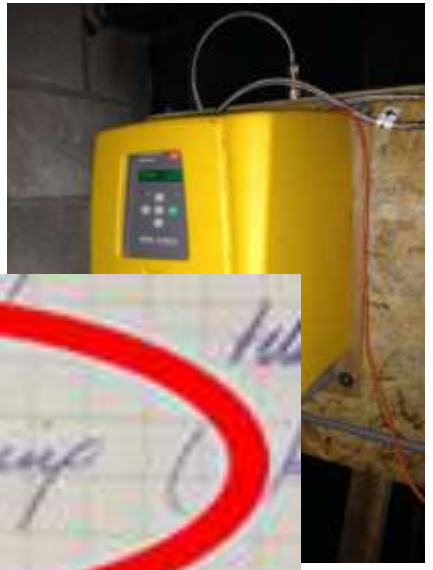
2 years of trouble-free operation, suddenly a huge peak in corrosion

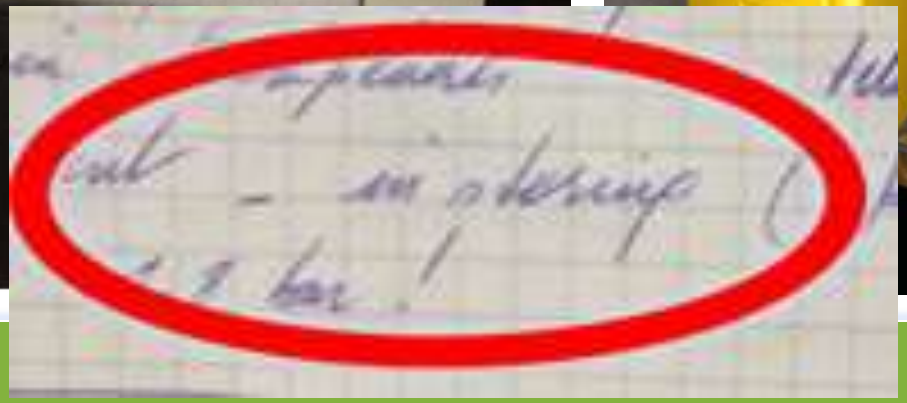


After a little investigation, the vacuumdegasser reveals to have a problem…

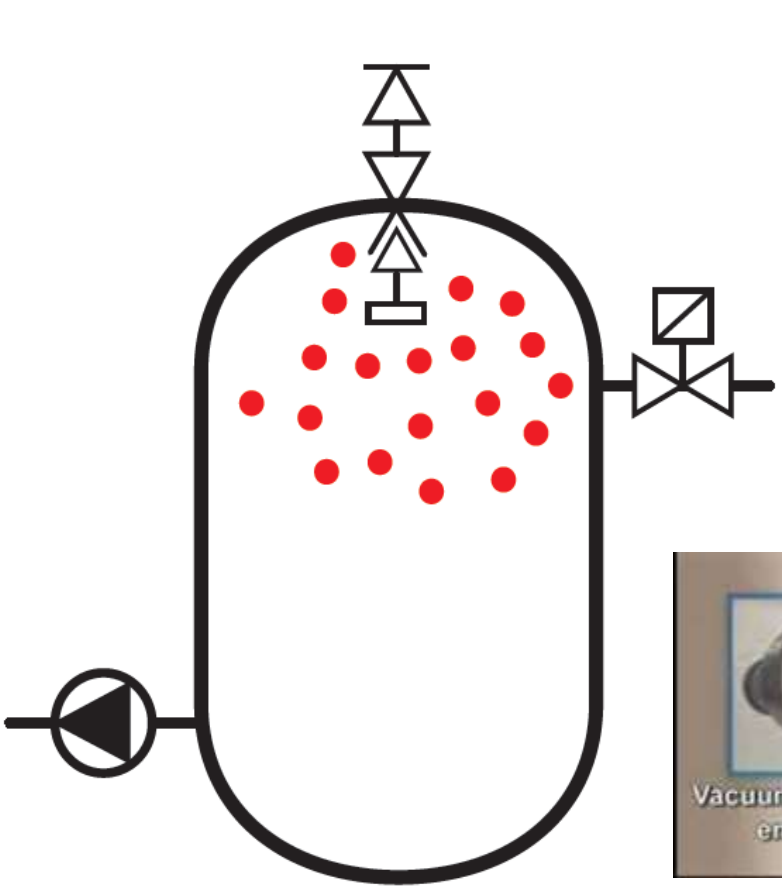
Logbook mentions a problem with the degasser, inspection shows …

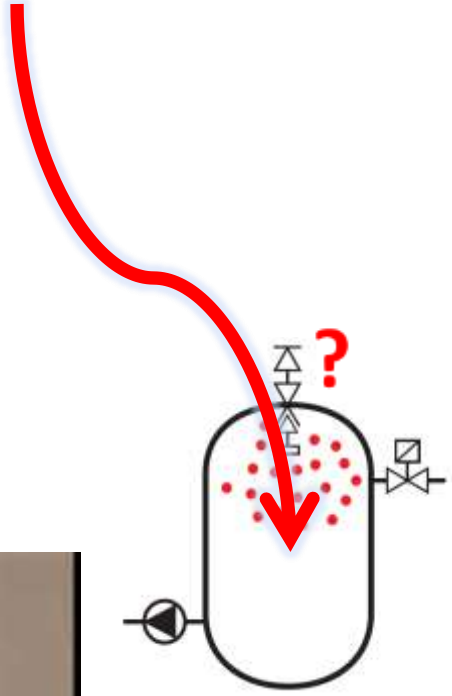




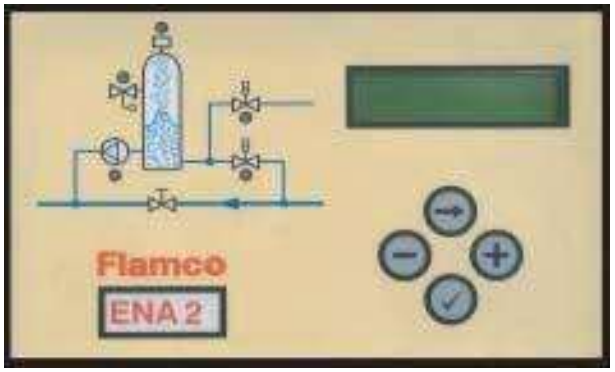


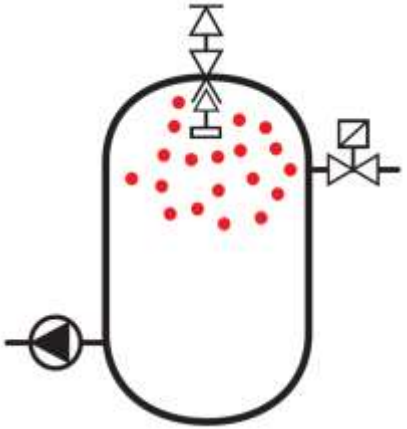
Some vacuum degassers on the market continue pumping, even if they have a malfunction

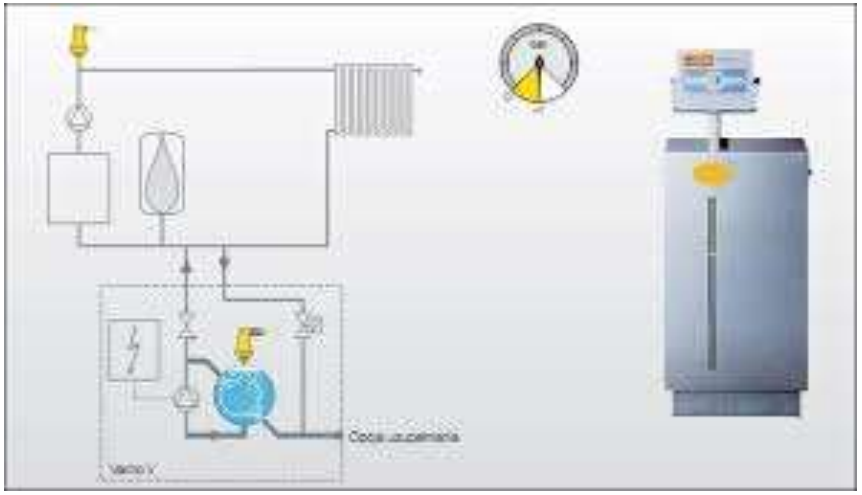


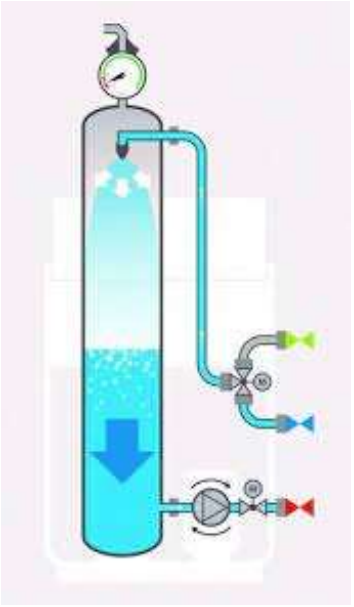


Well known brands:
Flamco, Reflex, Pneumatex, Spirotech

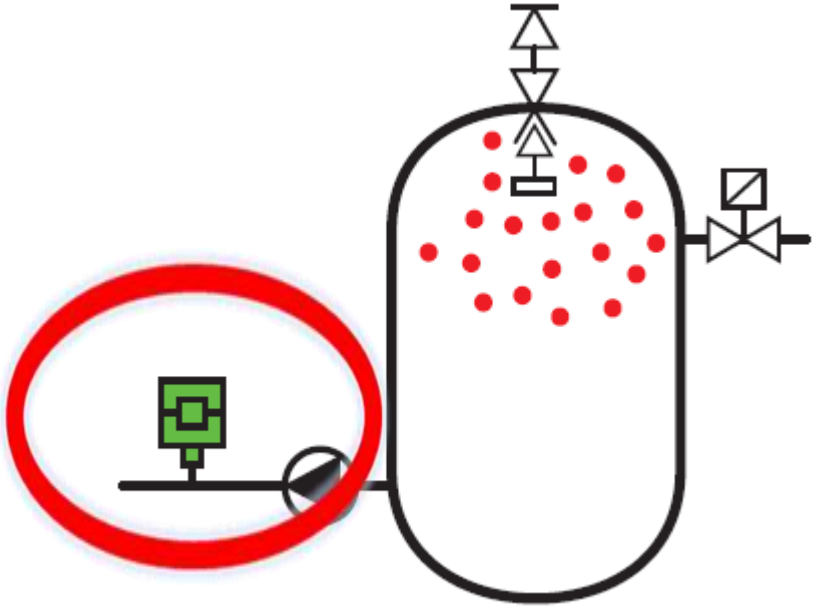


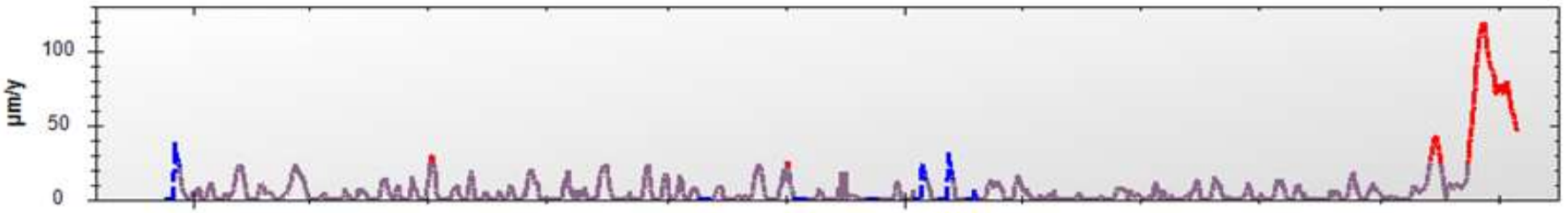






Conclusion: vacuum degassers must be corrosion-monitored



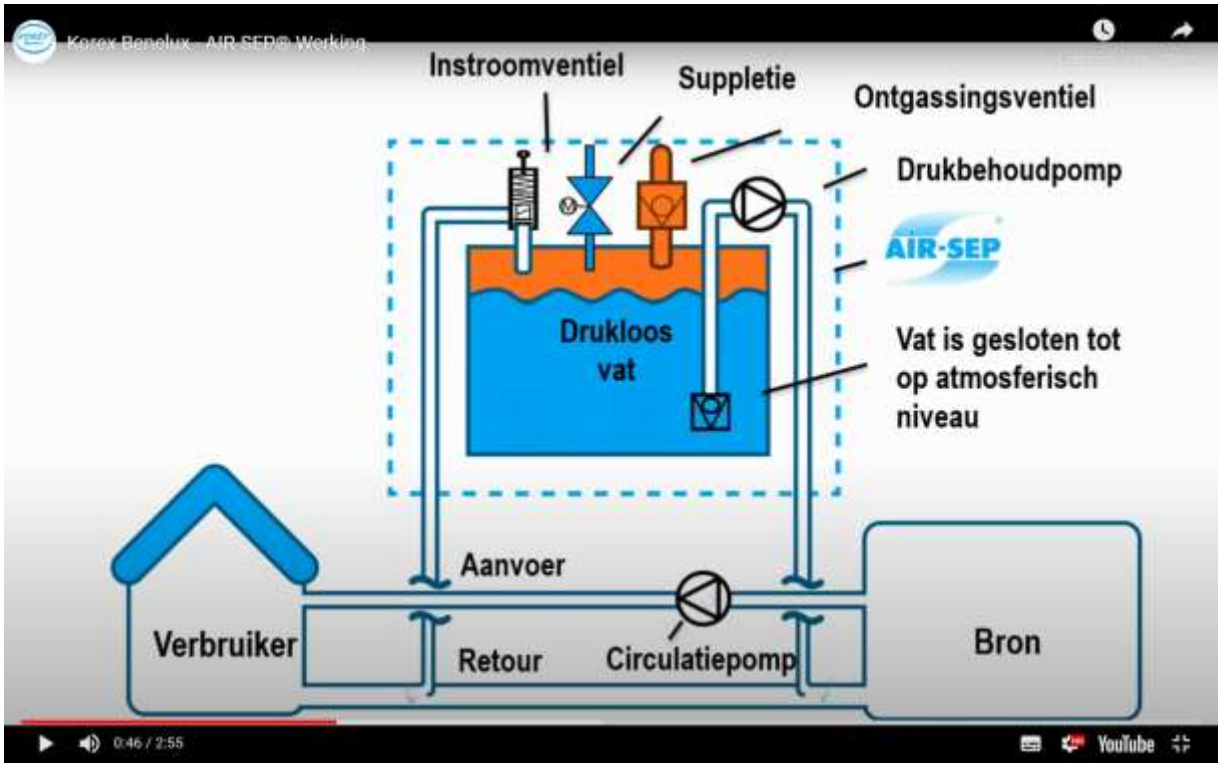


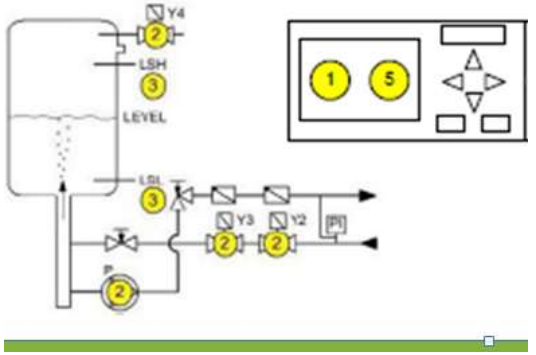
Combisystems: often a very well hidden menace

combi expansion and degassing

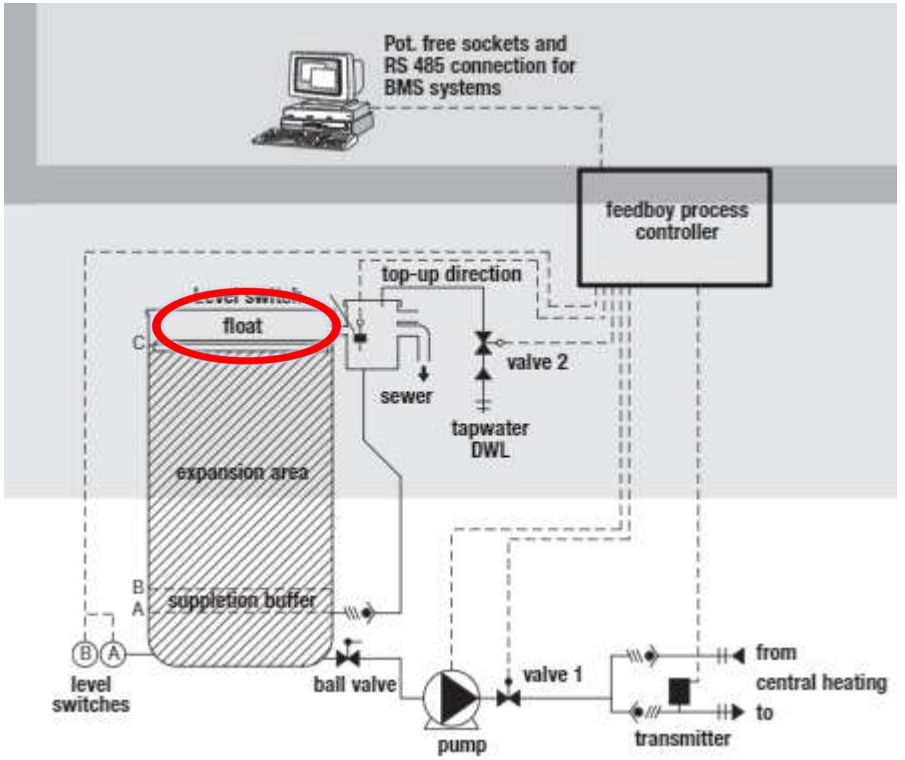
and oxygenating !

Korex and Olymp have an open degassing vessel that looks closed





Flexcon Feedboy (not available anymore) has a PU float

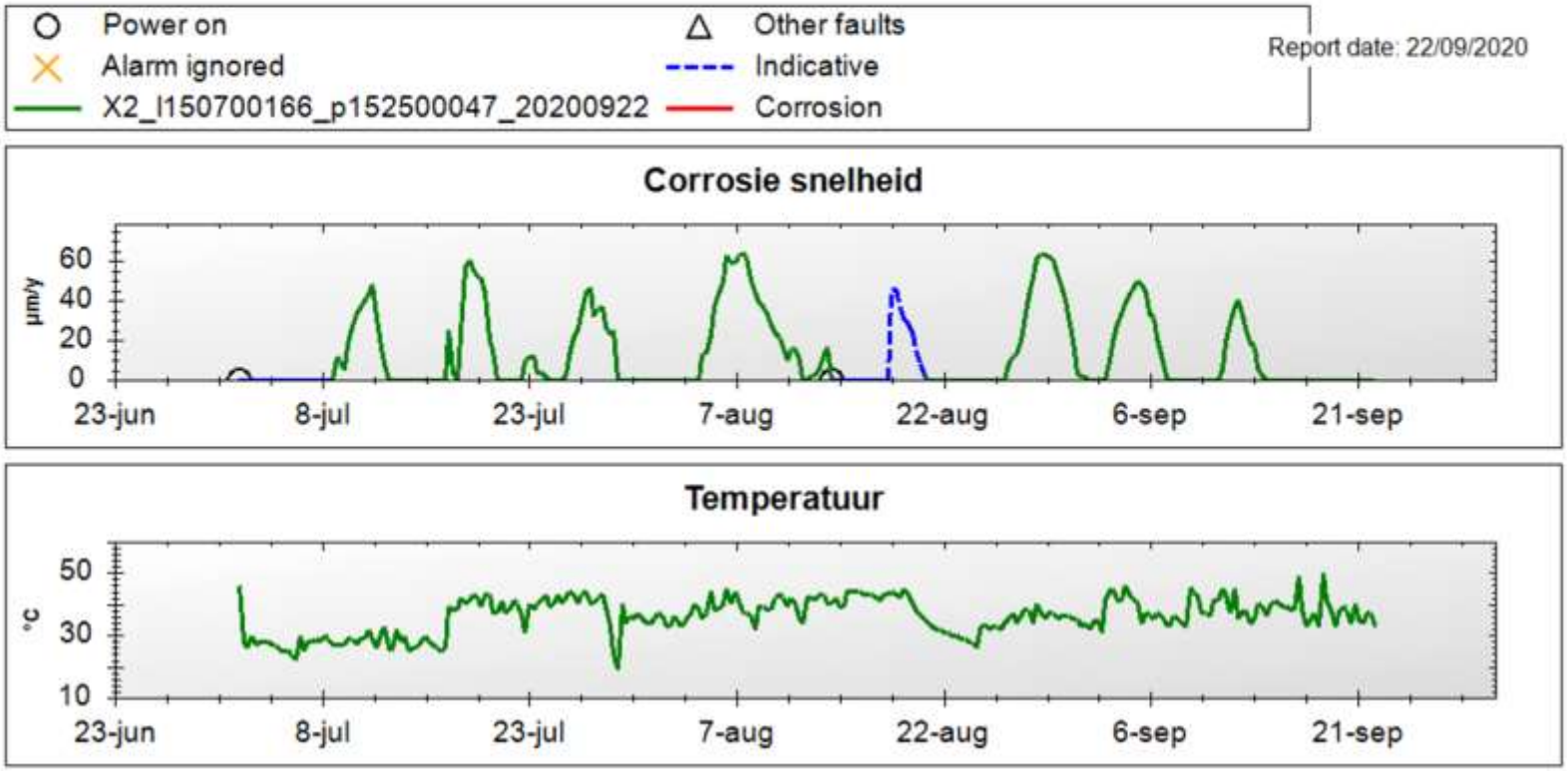


The interior speaks for itself

And this tank is made of STAINLESS STEEL !!!

The rust deposit originates from the pipes of the system !!!

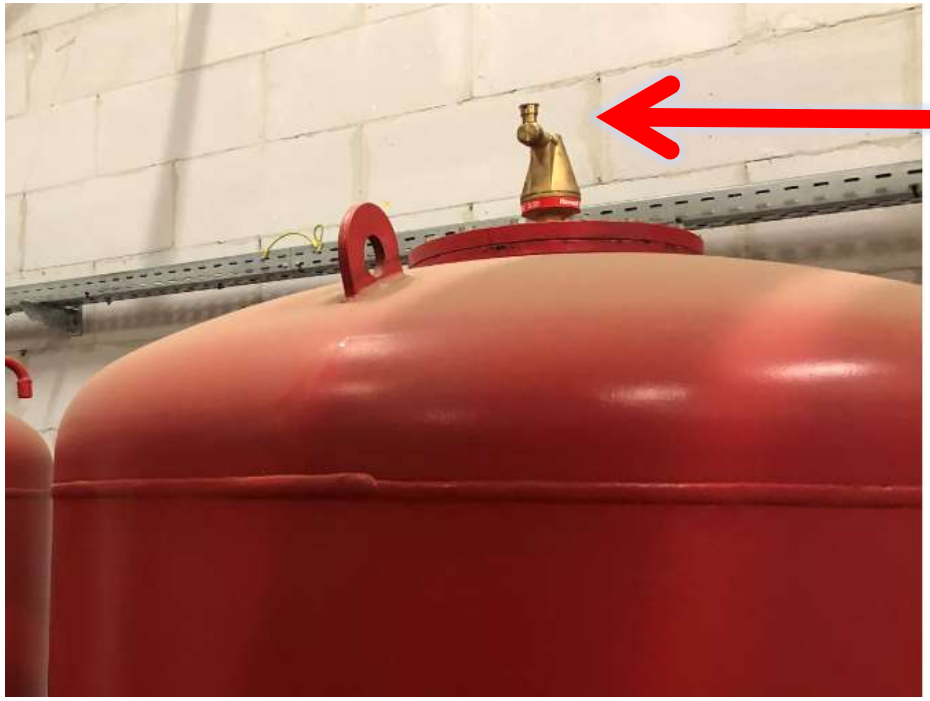
Combi expansion system (expansion + degassing combined): DEFUNCT VACUUM RETAINER VALVE

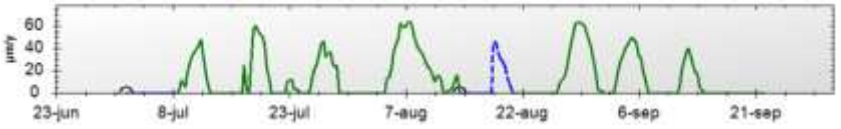


One small Risycor in a very remote part of a system over 100m3 detects a recurring corrosion pattern

In the main boiler room, I discover an interesting detail

Automatic air vents WITH non return valve





That were NOT screwed airtight, but mounted loose !!!

→

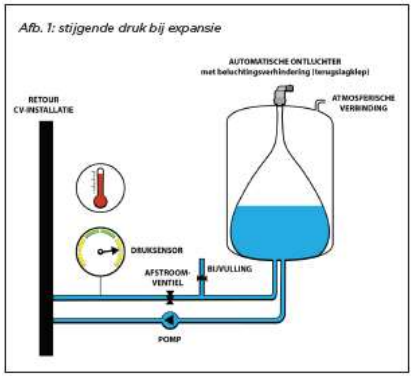
These tanks become open tanks that breathe !!!

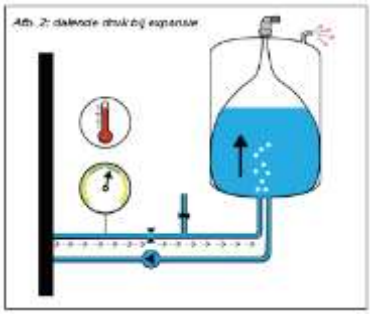
Flamcomat and Reflex Variomat have the same functional principle

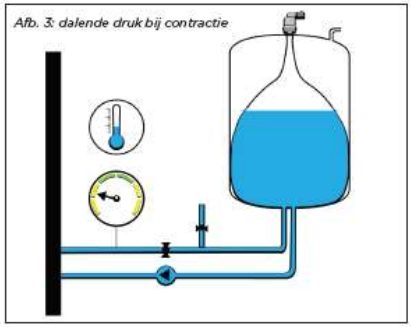
Most sadly there is also a “Rubbergate”

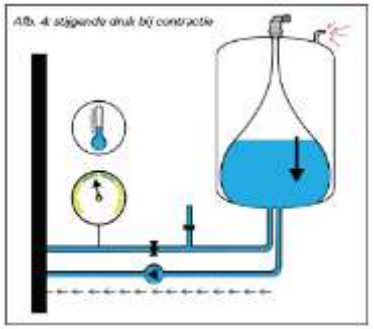
VERTROUWELIJK EN ANONIEM ONDERZOEK NAAR EEN MOGELIJK BELANGRIJKE CORROSIEVEROORZAKER

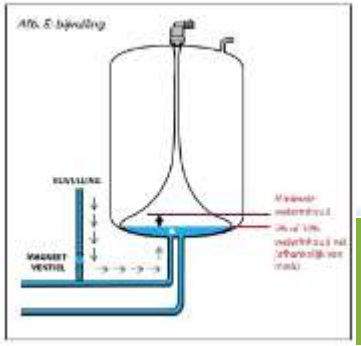
April 2020

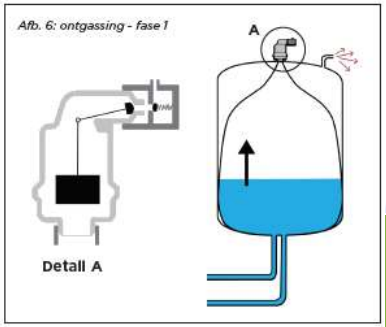








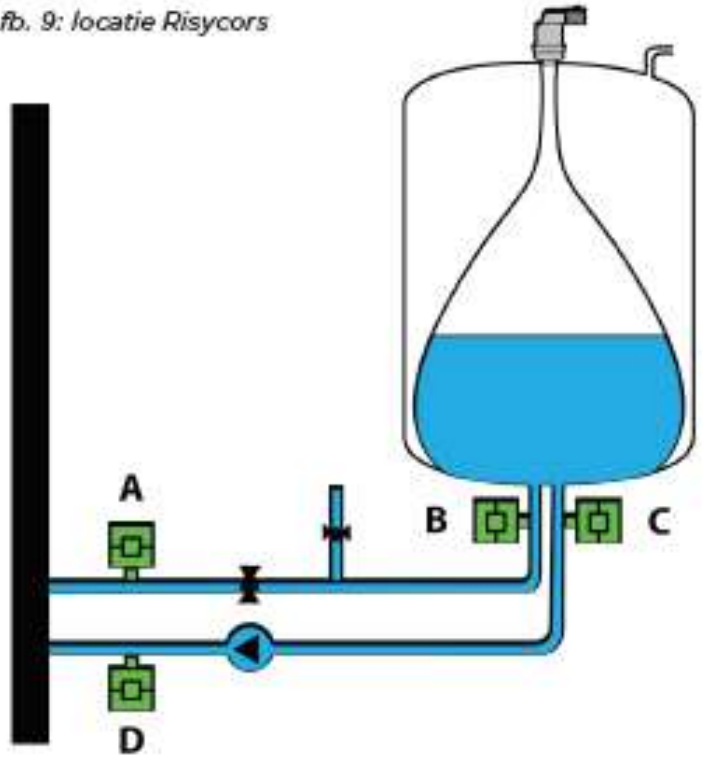




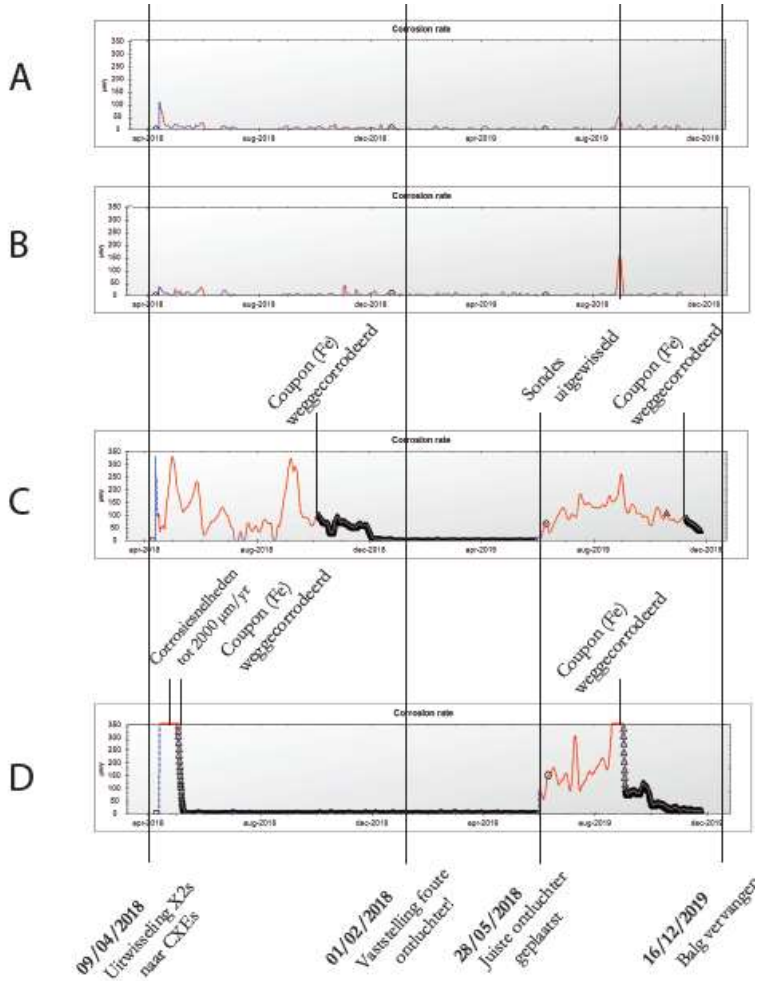
Afb. 8: EPDM balg in een Reflex Variomat

Permeability coëfficiïent (cm^3-cm x 10^-8/cm^2-s-atm)		
Gas	**IIR**	**EPDM**
Lucht	.6	7.9
CO2	3.92-5.18	85
H2	5.5	29-111
He2	6.4	19.7
Stikstof	.24	6.4
Zuurstof	**.99**	**16-18**

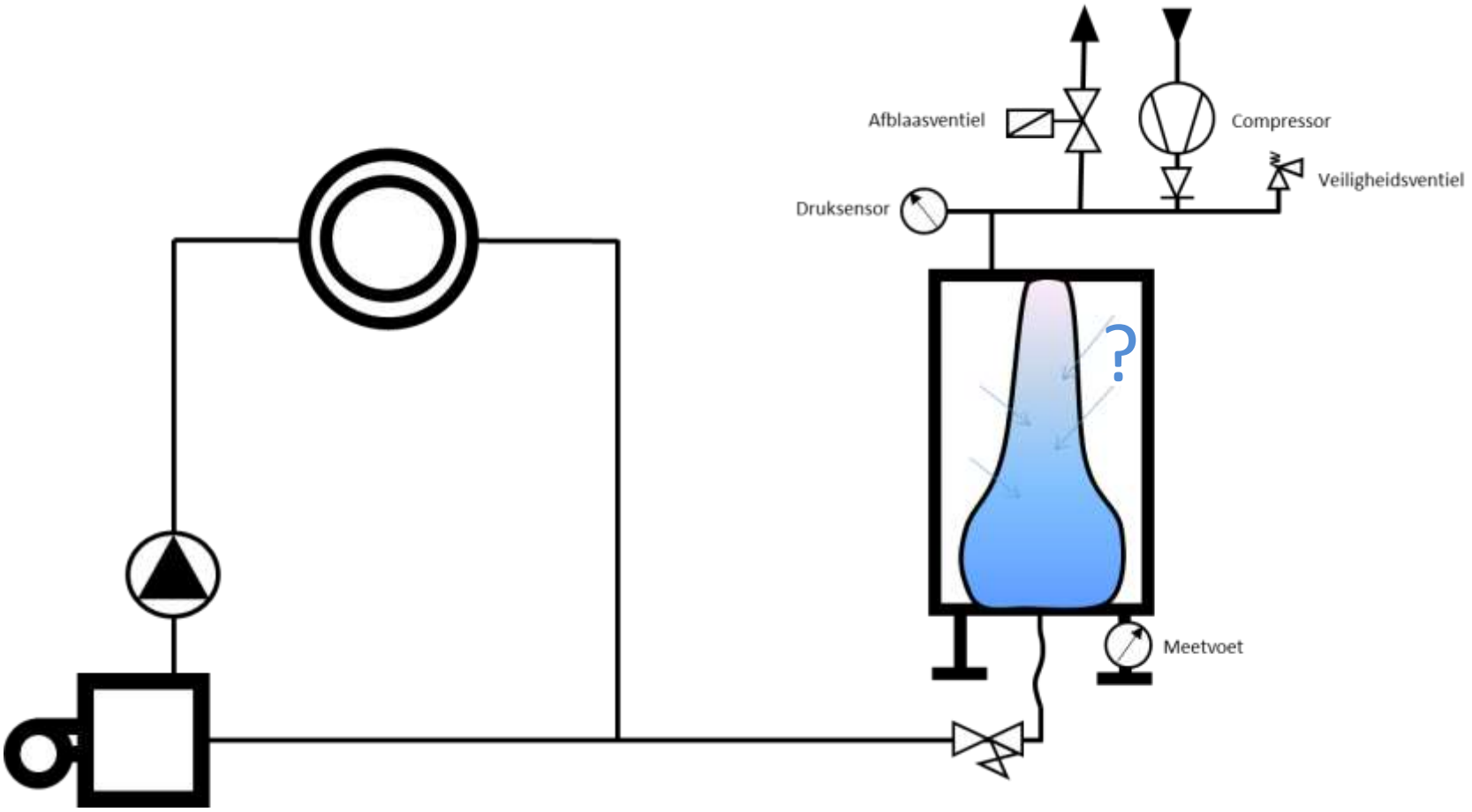
Afb. 9: locatie Risycors



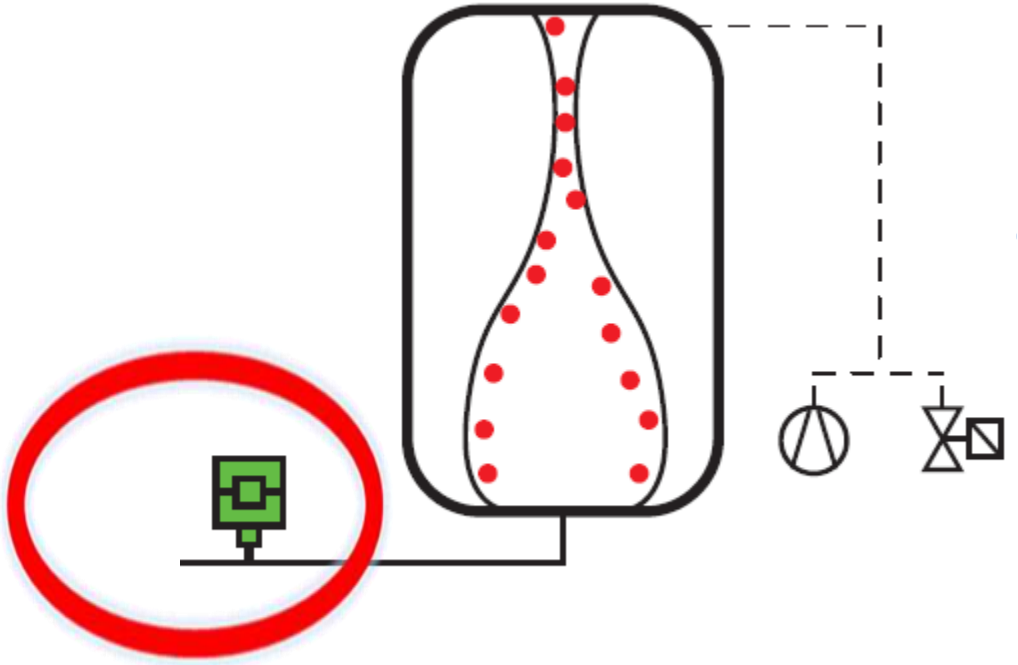
Afb. 12: vier Risycor CX-en gemonteerd in de installatie



Finally: compressor systems



Conclusion: compressor systems must be corrosion-monitored



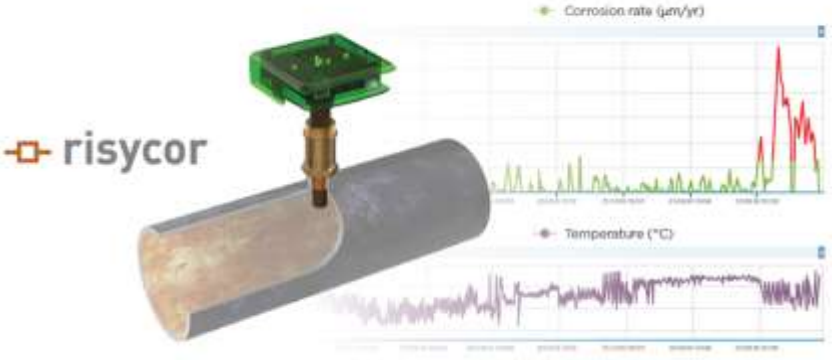
Corrosion monitoring:

- ✓ Desired security level
- ✓ Budget
- ✓ Technical complexity
- ✓ Ease of problem solving

WTCB/CSTC writes:

Aangezien corrosie een sluipend verschijnsel is, wordt aanbevolen om – ook in kleinere installaties – in corrosiemonitoring te voorzien

La corrosion étant un phénomène insidieux, il est recommandé de mettre en place un monitoring, et ce même dans les petites installations



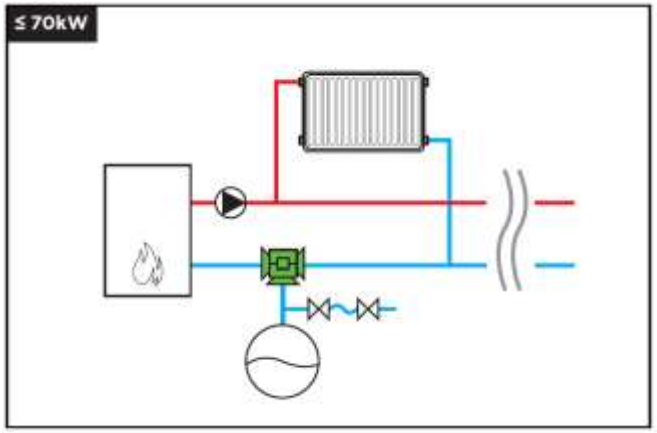
3 possible scenarios

✓ **Minimal** : one Risycor per system

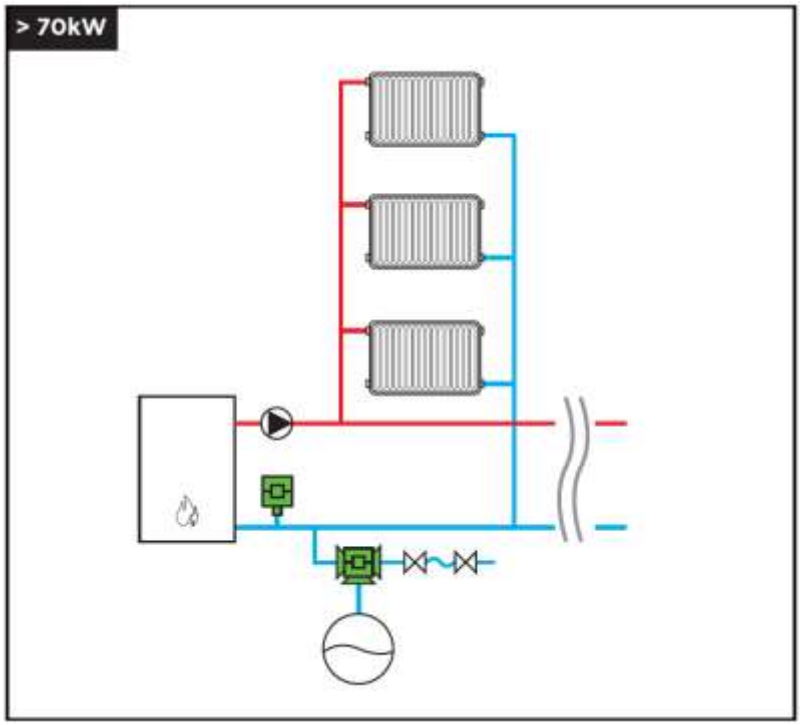
✓ **Optimal** : minimal +
- ✓ one Risycor per RISK CIRCUIT
- ✓ one Risycor per RISK COMPONENT

✓ **Ideal** : optimal +
- ✓ one Risycor in return of every riser

Application guideline: Minimal

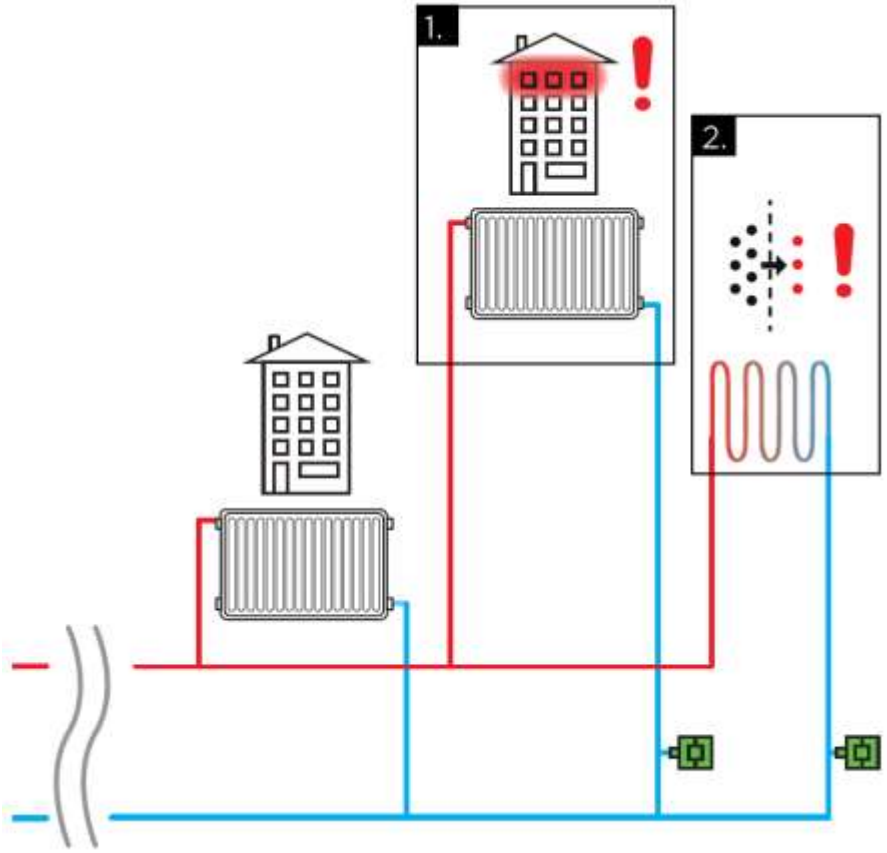


All in ca. 500€



All in ca. 1500€

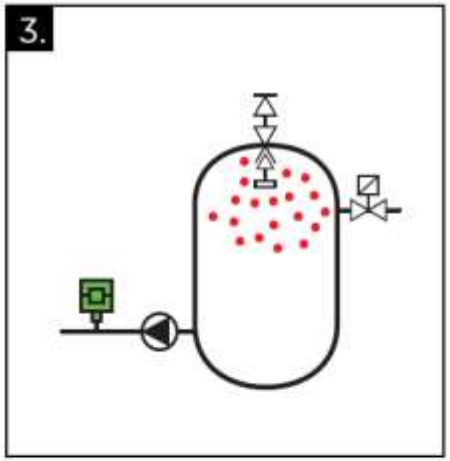
Application guideline: Optimal

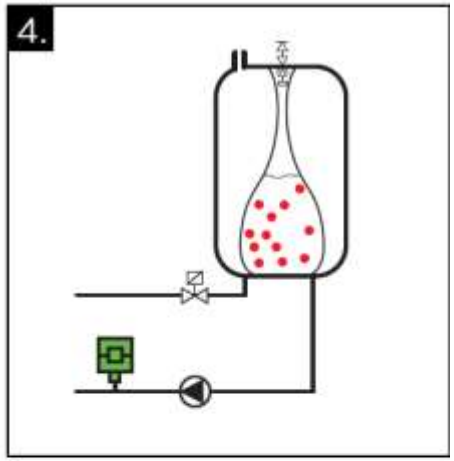


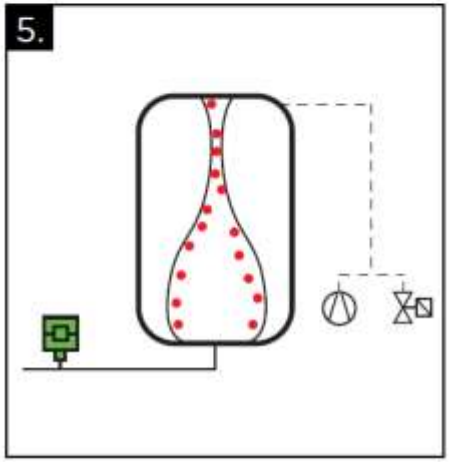
Circuits @RISK for oxygen entry:

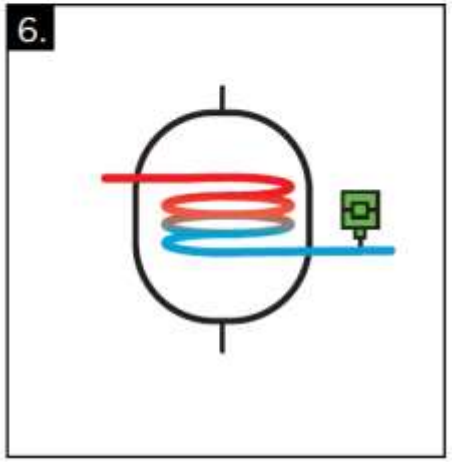
- ✓ Highest point
- ✓ Non-oxygen tight synthetics
- ✓ Rubber hoses

Application guideline: Optimal







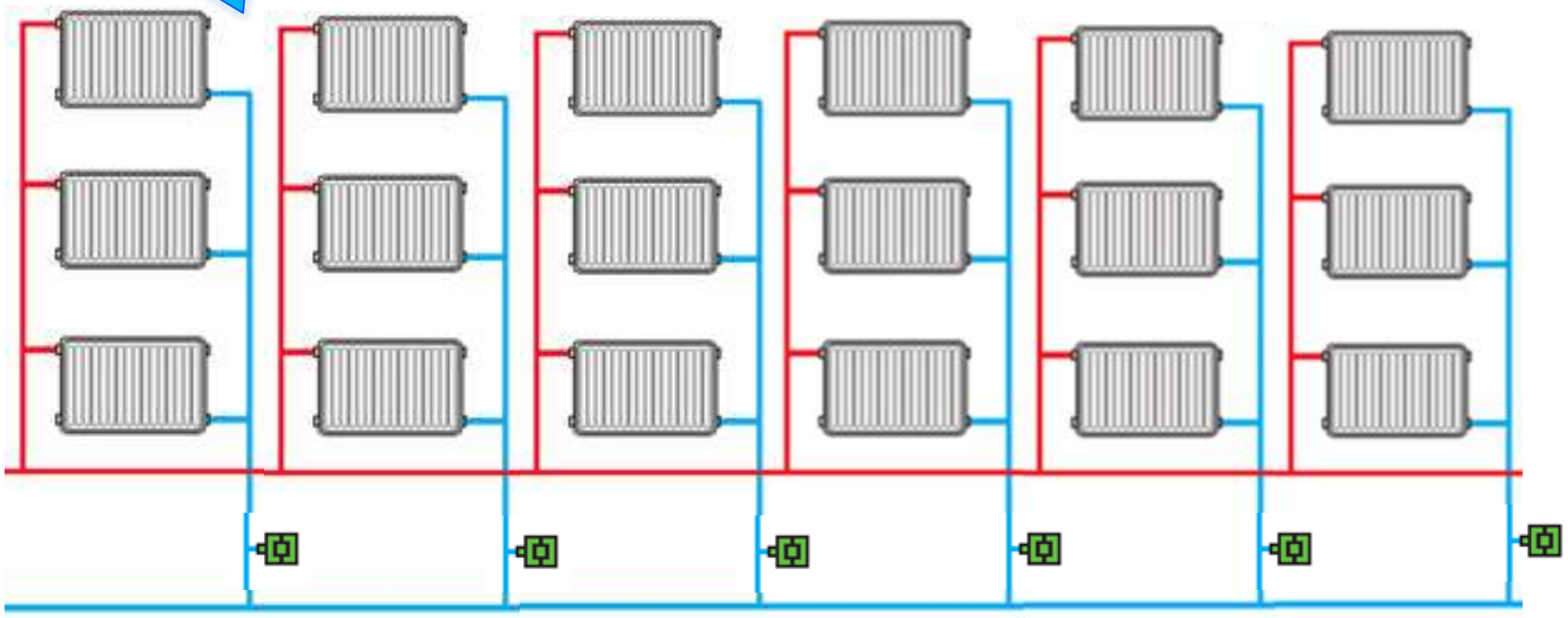


Components @RISK for oxygen entry:

3. pressure step- (or vacuum) degassers
4. combi- pump expansion systems (degassing within the bladder)
5. Compressor expansion systems
6. domestic hot water generation

Application guideline: Ideal

In the return of every riser



Alternative “Ideal low cost” (TXV)

Look forward