RH-measuring challenges

- Moisture flow balance problems in vapor tight concrete
- Heat effects from drilling

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Field operatives

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Polygon/AK (regarding concrete)

- 33 RBK technicians
- Specialists in moisture safe design
- Specialists in moisture safe construction
- Laboratory capabilities
- Temporary climate soloutions
- Moisture damage control, investigation, mitigation

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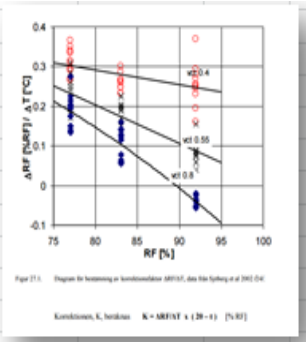
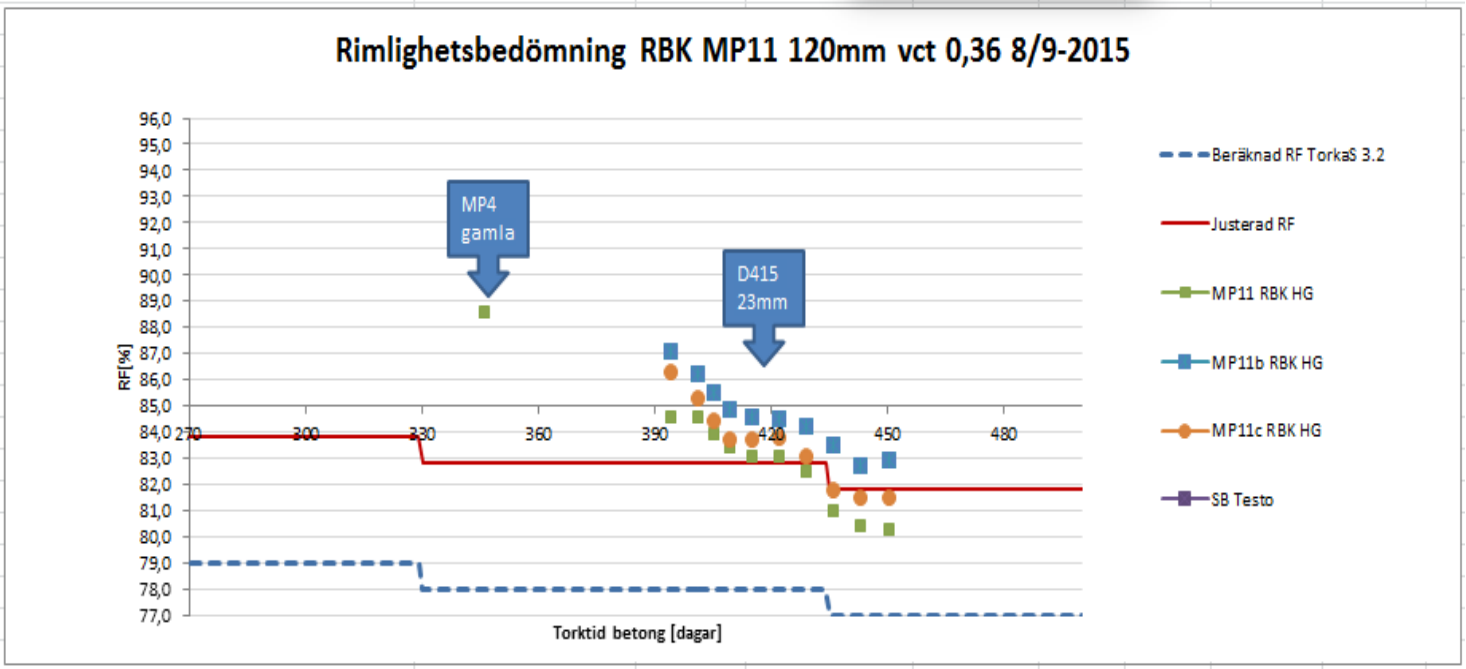
It started out with a tool to evaluate field data
High readings and fast drying with low wcr?

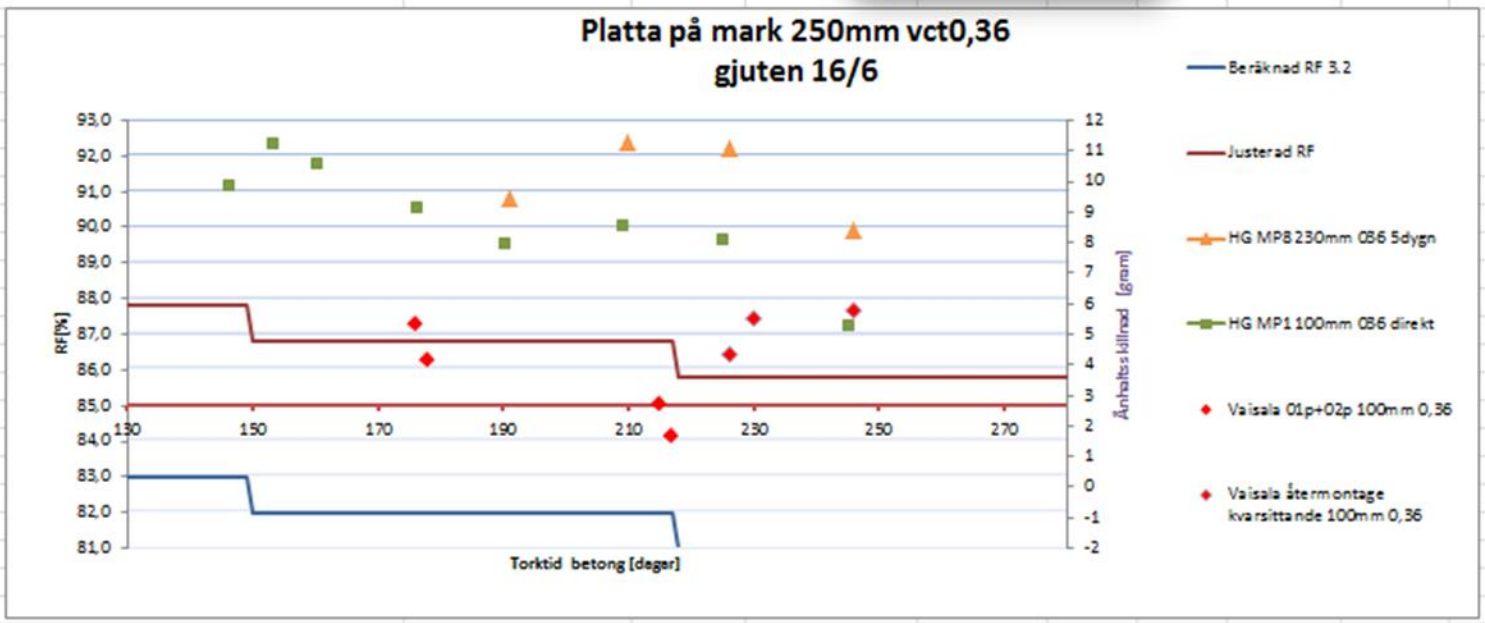
vct	0,36	
påslag vct 3,2 [%RF]	4,8	
påslag RBK osäkerhet[%RF]	0	
Påslag drift skiljer från 20 grader [%RF]	0,0	
Påslag avjämning [st dagar]	0,0	
Påslag försenad/forcerad torkstart [st dagar]	0,0	
ant. Torkmiljö [grader temp], [%RF]	18	45
ant. ånghalt 85 [g]	6,2	
ant. ånghalt 90 [g]	7,0	
ant. ånghalt 95 [g]	7,8	





We noted big spread in readings (low wcr with ongoing screeding)

vct	0,36	
påslag vct 3,2 [%RF]	4,8	
påslag RBK osäkerhet[%RF]	0	
Påslag drift skiljer från 20 grader [%RF]	0,0	
Påslag avjämning [st dagar]	0,0	
Påslag försenad/forcerad torkstart [st dagar]	0,0	
ant. Torkmiljö [grader temp], [%RF]	24	60
ant. ånghalt 85 [g]	5,3	
ant. ånghalt 90 [g]	6,4	
ant. ånghalt 95 [g]	7,5	



Crawled before we tried to run

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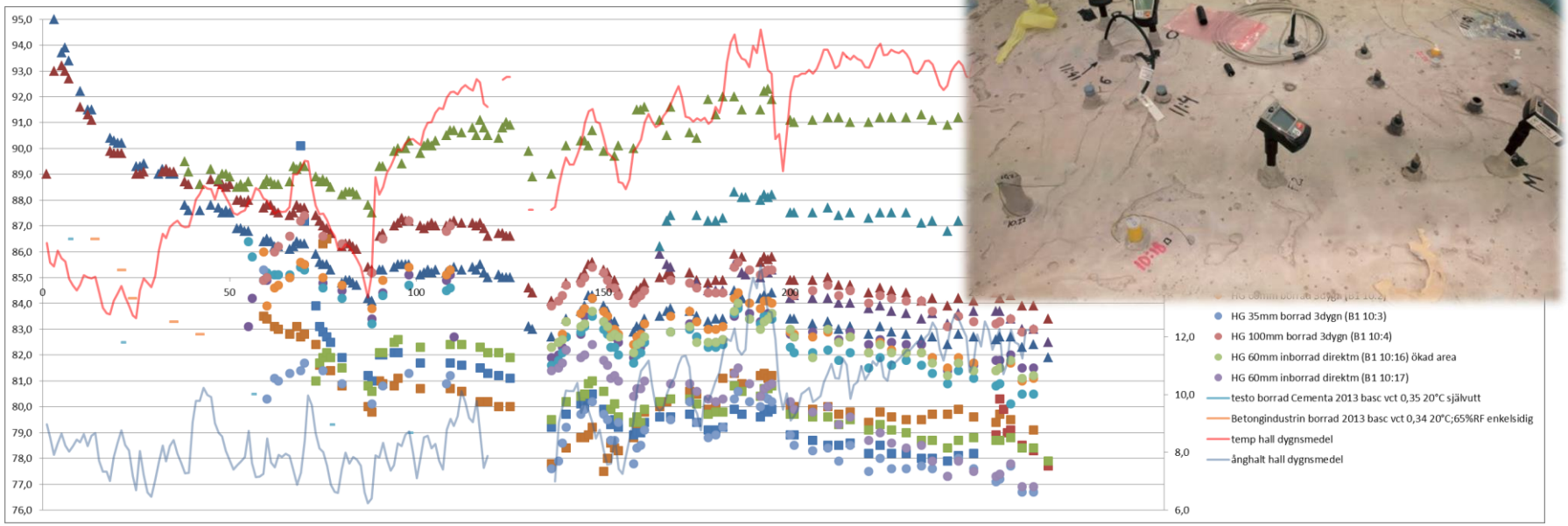
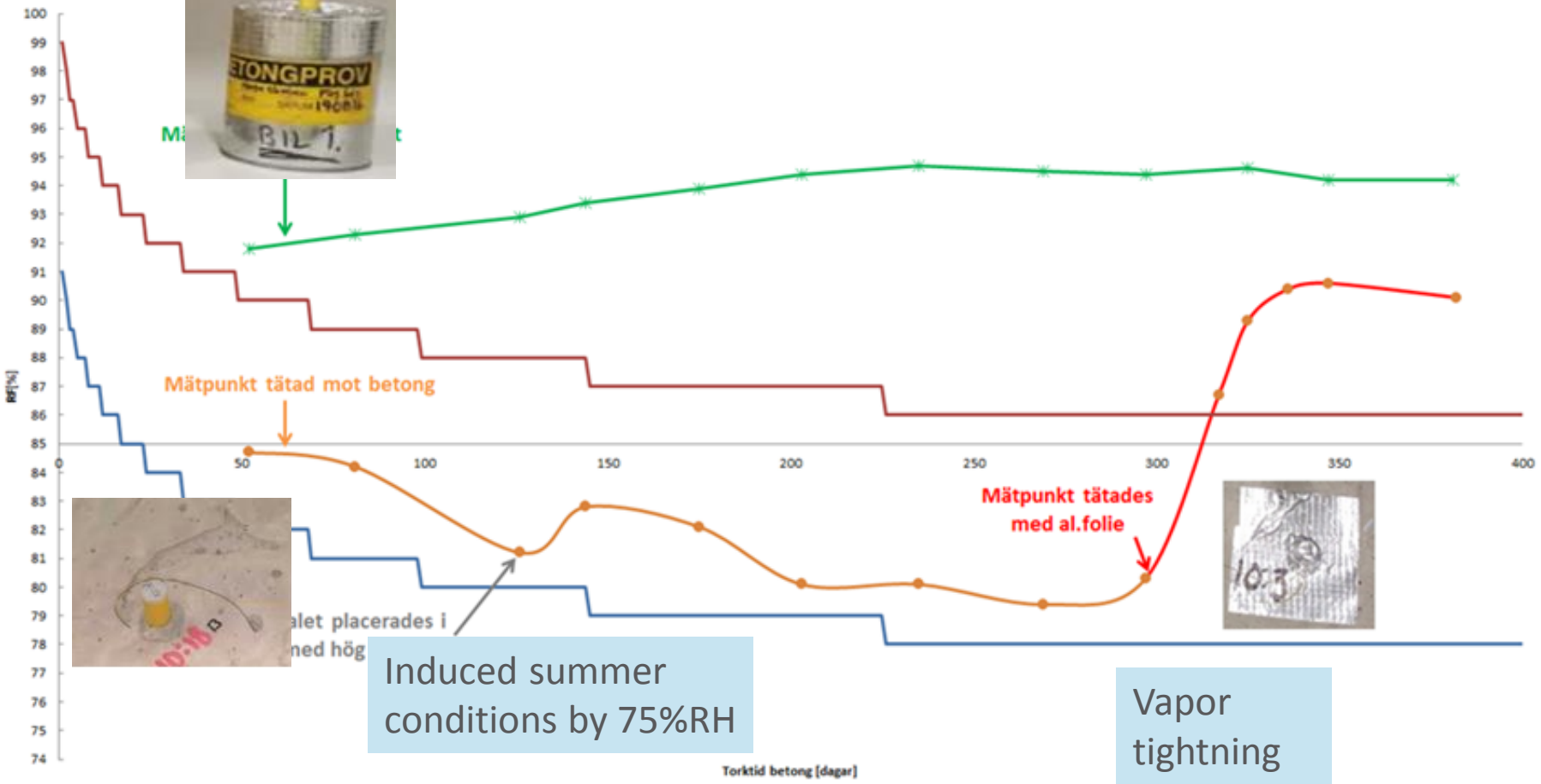
And then we made some more tests, and some more, and some more and… 2 years running now and still testing. What we found needs repeated readings over time to be able to see. Trends and behaviour not values put us on the right track. Mimicking field climate made new findings



And it got really interesting.

Rimlighetsanalys av mätningar i Burk & Betongblock Vct 0,34 (15% slagg)



Induced summer conditions by 75%RH

Vapor tightning

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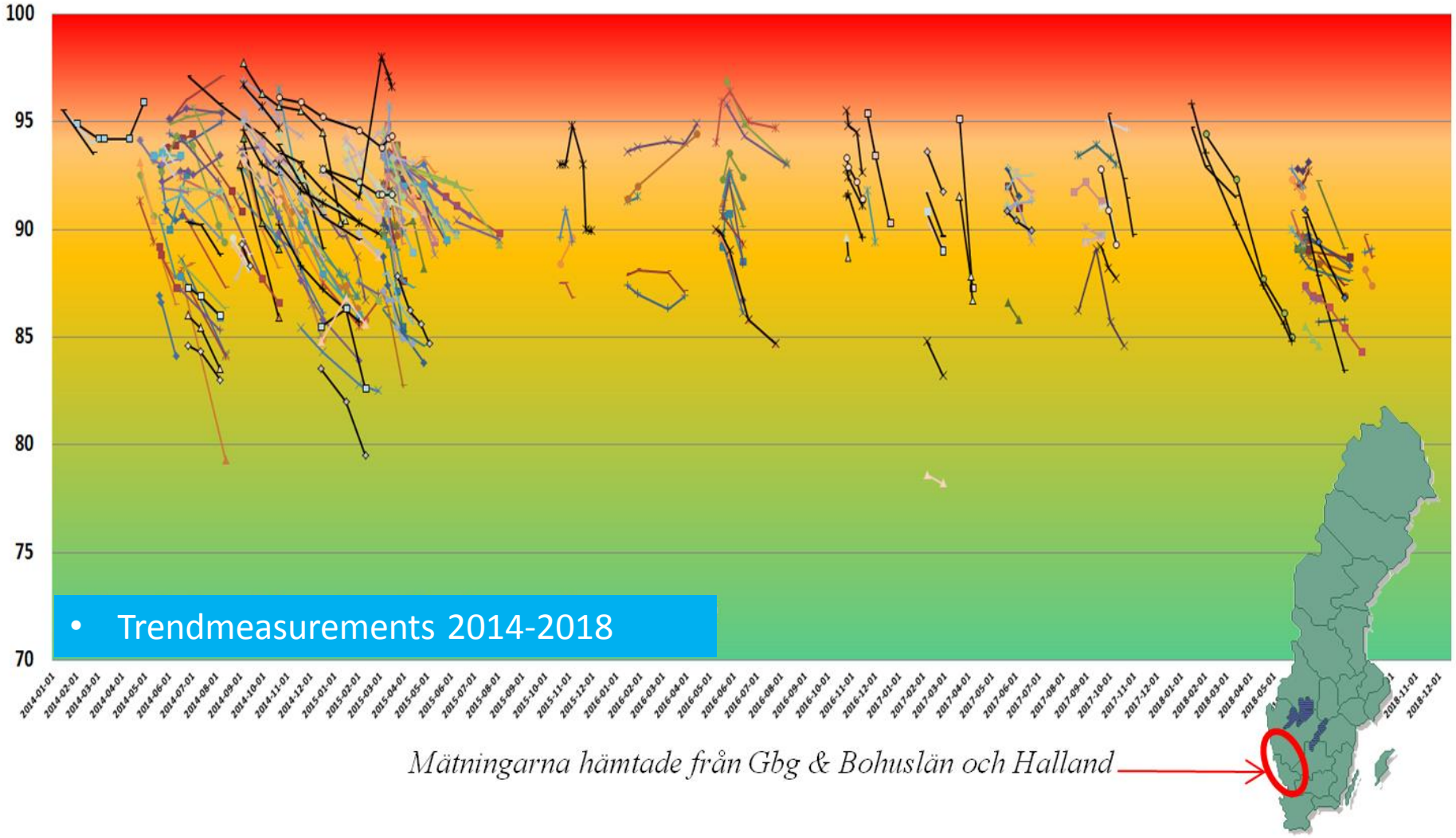
It matched in situ data



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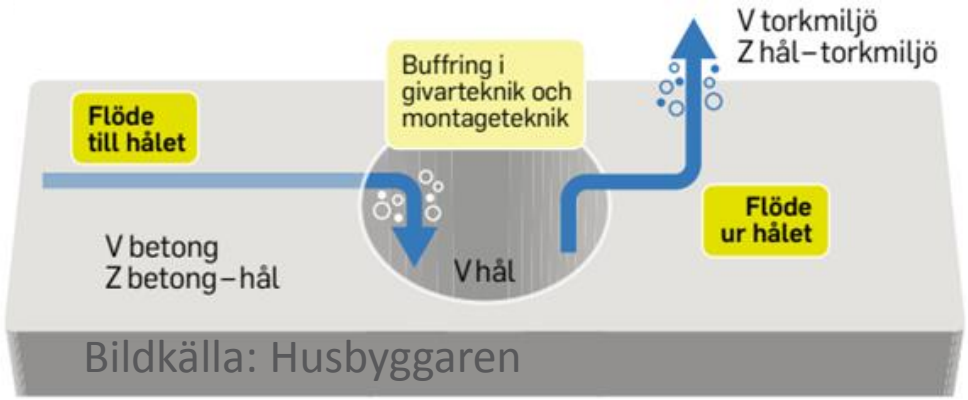
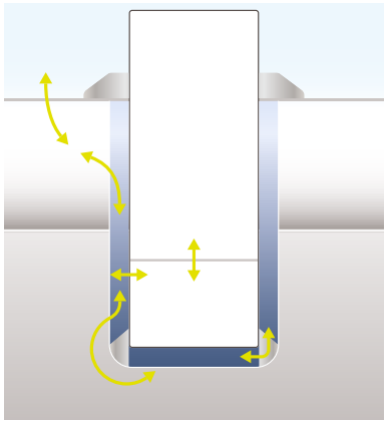
Flow balance = we will always miss the target





RH/vapor gradient	Relative resistance in concrete	relative resistance in sleeve	Measured value inside hole (concrete 85%RH)	Season effects
20°C 85-20 RH	1	200	84,7	Winter
20°C 85-20 RH	1	100	84,4	Winter
20°C 85-20 RH	1	10	79,1	Winter
20°C 85-60 RH	1	10	82,7	Summer

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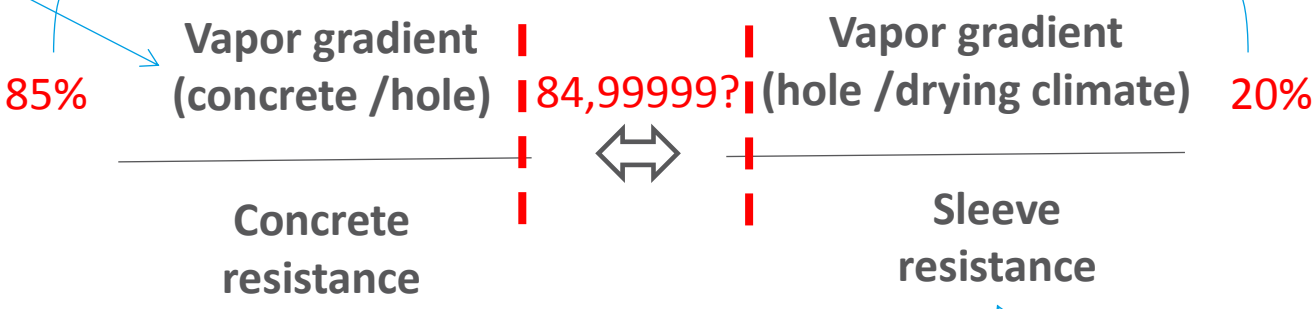
The ”balance error” will typically increase over time and vary by drying climate.

Will change by temperature (vaporcontent in concrete)

With decreasing total vapor gradient the error can vanish

Will change by vapor content in air



Will always increase by time due to drying of the surface in the hole and by maturing processes in the concrete that add resistance. Will decrease with higher temperature.

Can decrease by time due to mechanical damage… Decrease in vapor open materials

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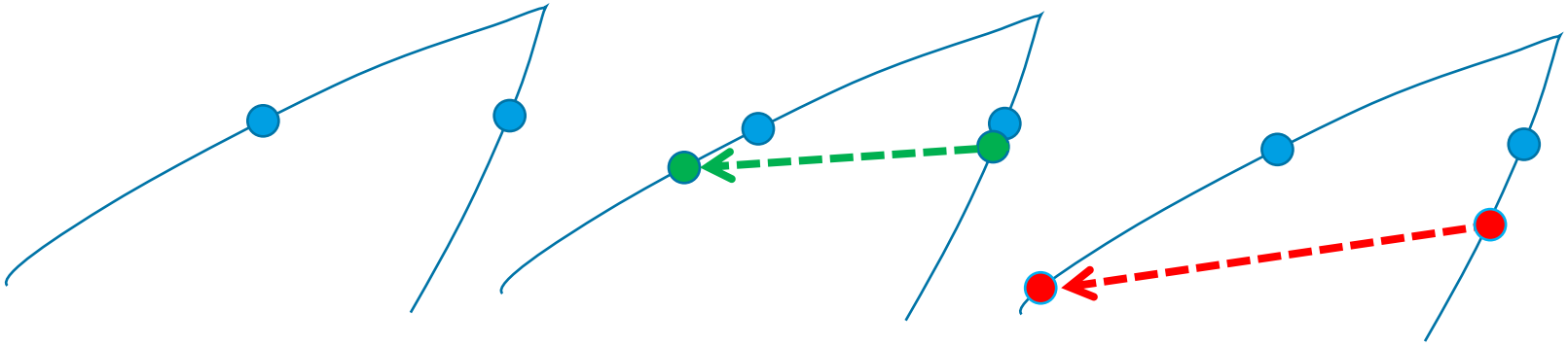
Leakage and resistance will effect how flowbalance is reached



Actual values

Reachable values

Leaky values

We will always target **absorption first**. To reach desorption we need the surface in the hole to start drying. This will introduce a moisture profile in the hole that will increase the measuring error. When desorption balance is reached is hard to predict and evaluate. The measured RH error can be huge if the desorptionisoterm is flat and the sleeve fittings are leaky.

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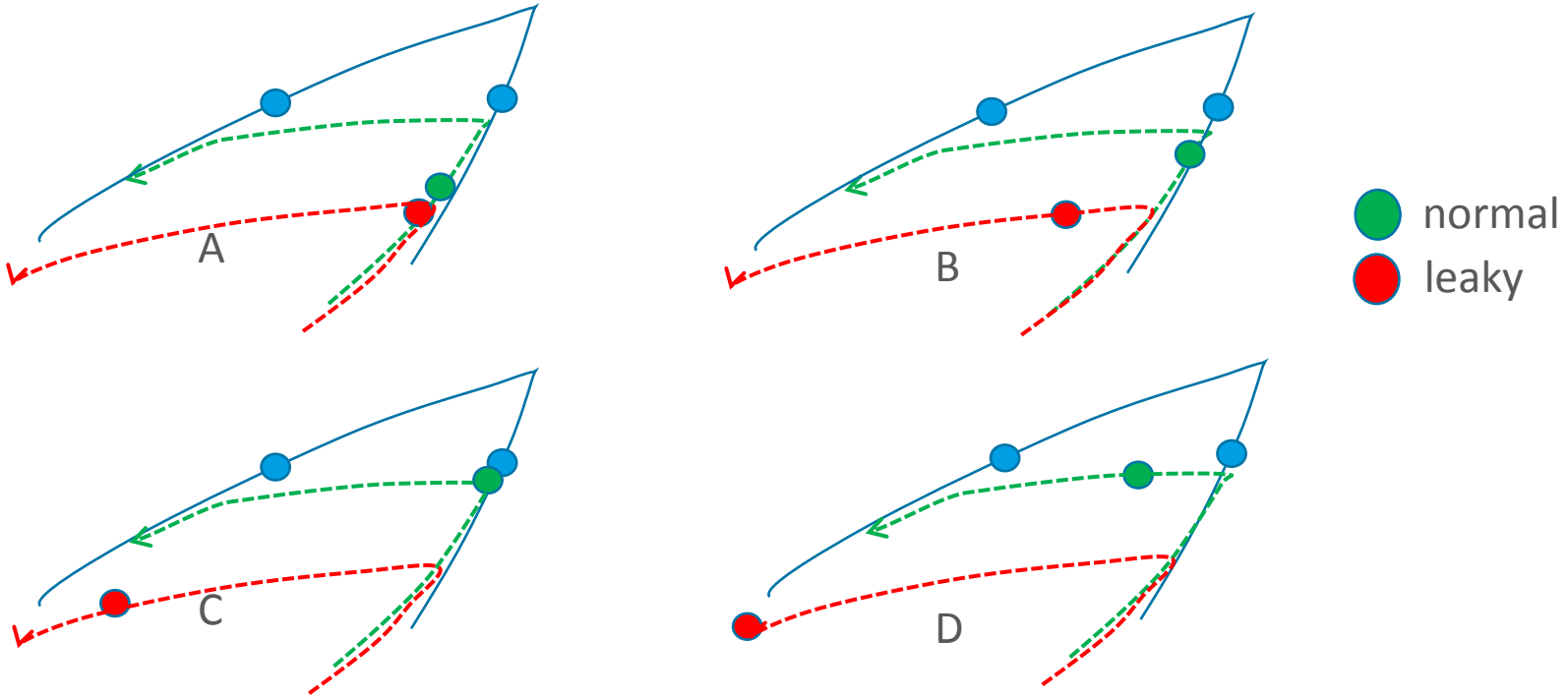
The timeframe depends by diffusion to and from the hole and also include buffering effects



Better sleeve techniques have transformed normal readings from red towards green. High sensor buffering will also slow down the absortion process and promote lower early readings . No drying of concrete in this example.

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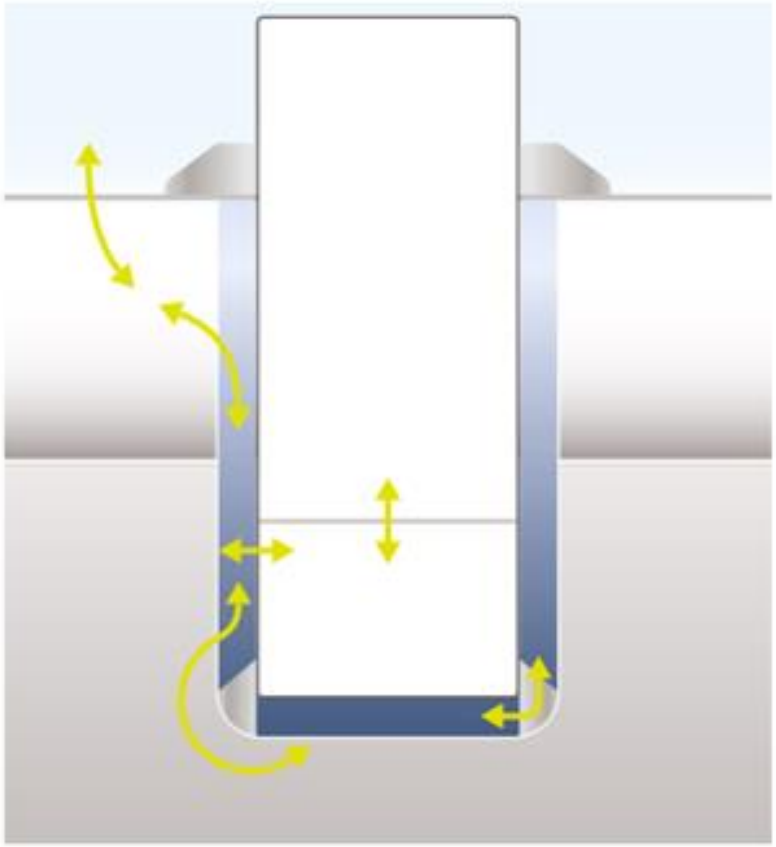
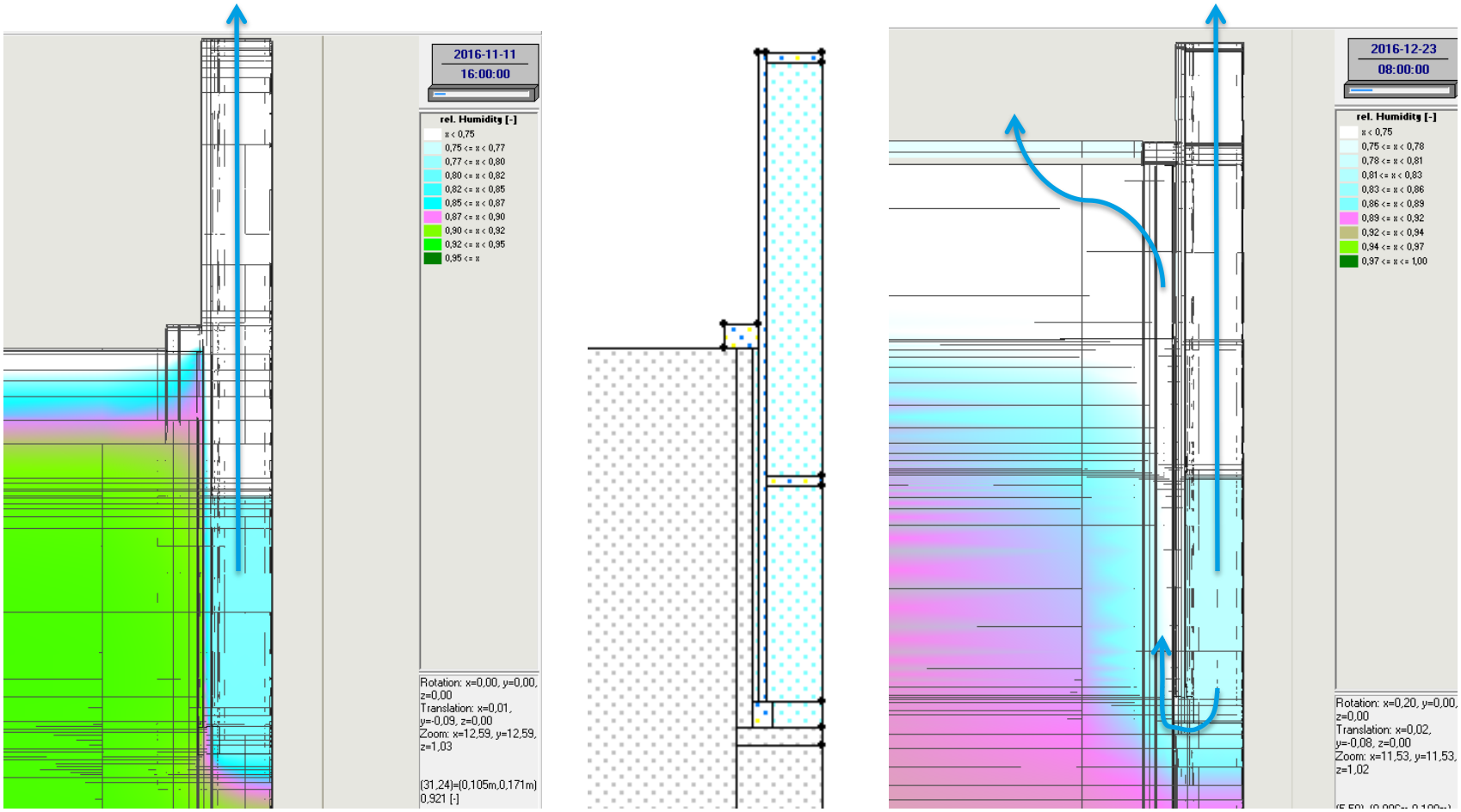
We get vapor transport around fittings throgh concrete and towards the vertical moisture profile



Leakage throuh levelling products was found to add big balance error.

Too high readings if wet
Too low if dry !

It´s possible to model the behaviour



Left with no sleeve leakage in concrete
Right adding vapor open screed and airgap between sleeve and concrete

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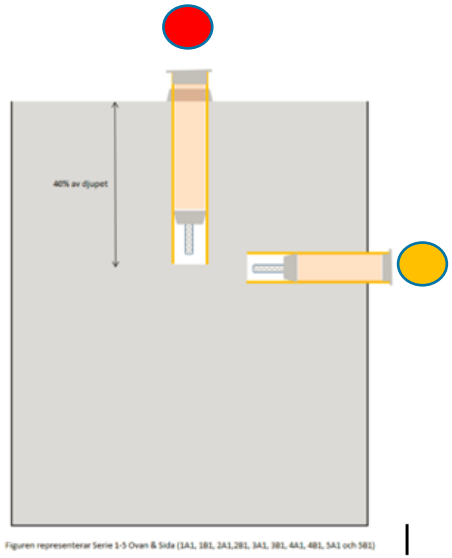
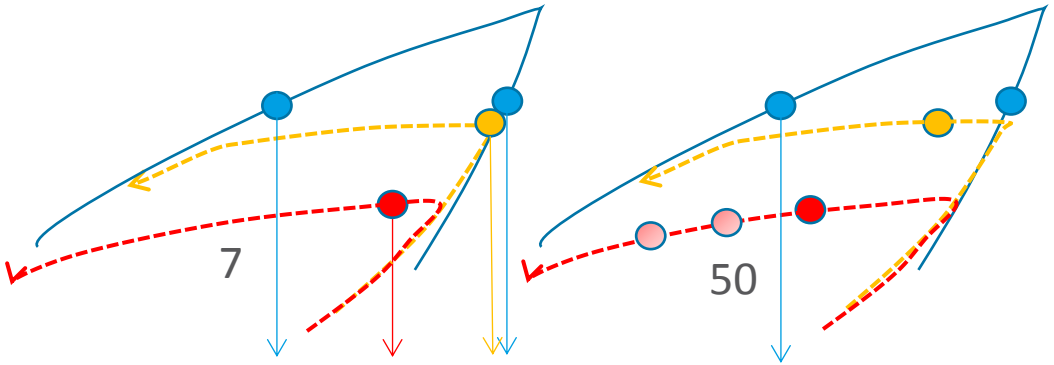
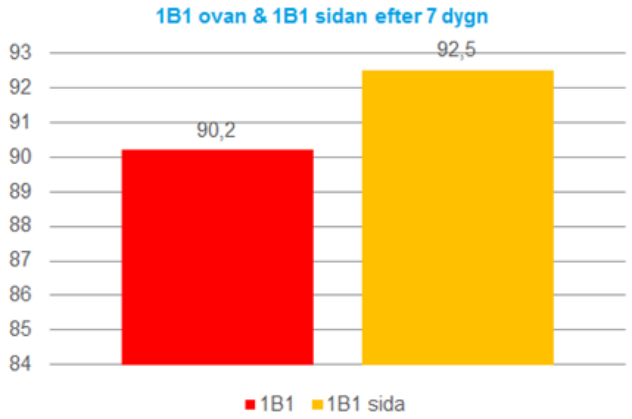
Steel jars from top and side 7 and 50 days, at same depht

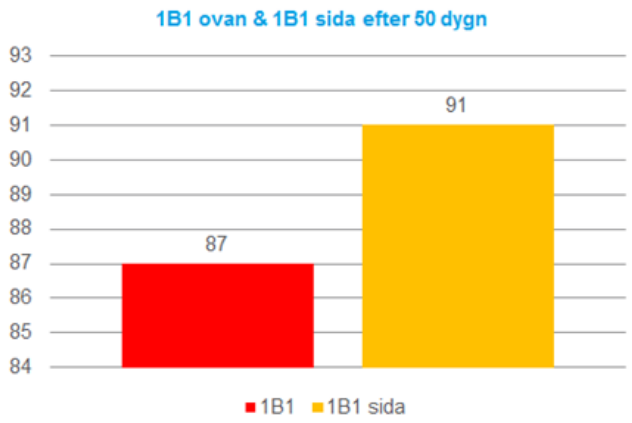


Figuren representerar Serie 1-5 Ovan & Sida (1A1, 1B1, 2A1,2B1, 3A1, 3B1, 4A1, 4B1, 5A1 och 5B1)



Note: Not the actual moisture level that is measured. Moisture in the surface of the hole minus balance error is measured.





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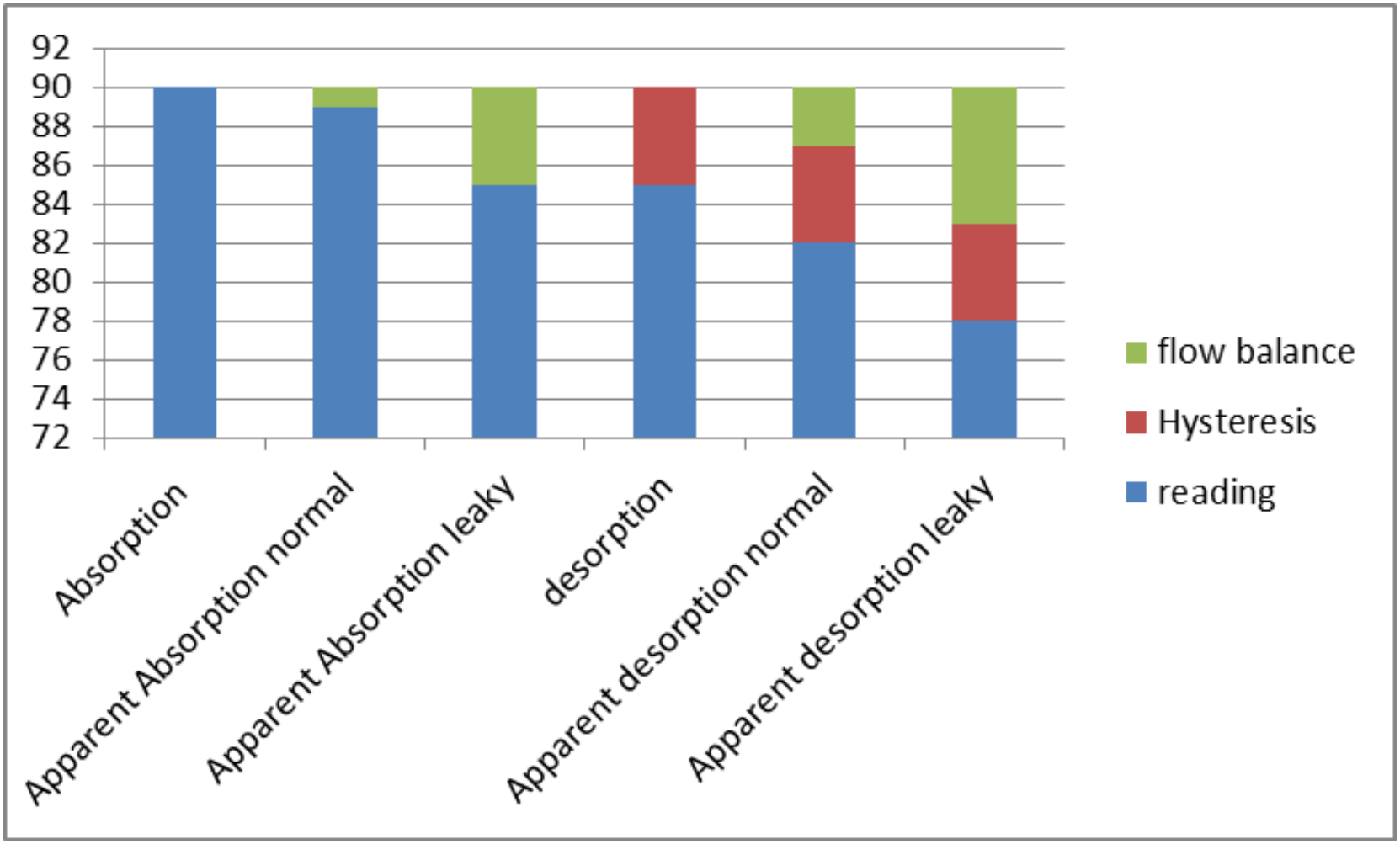
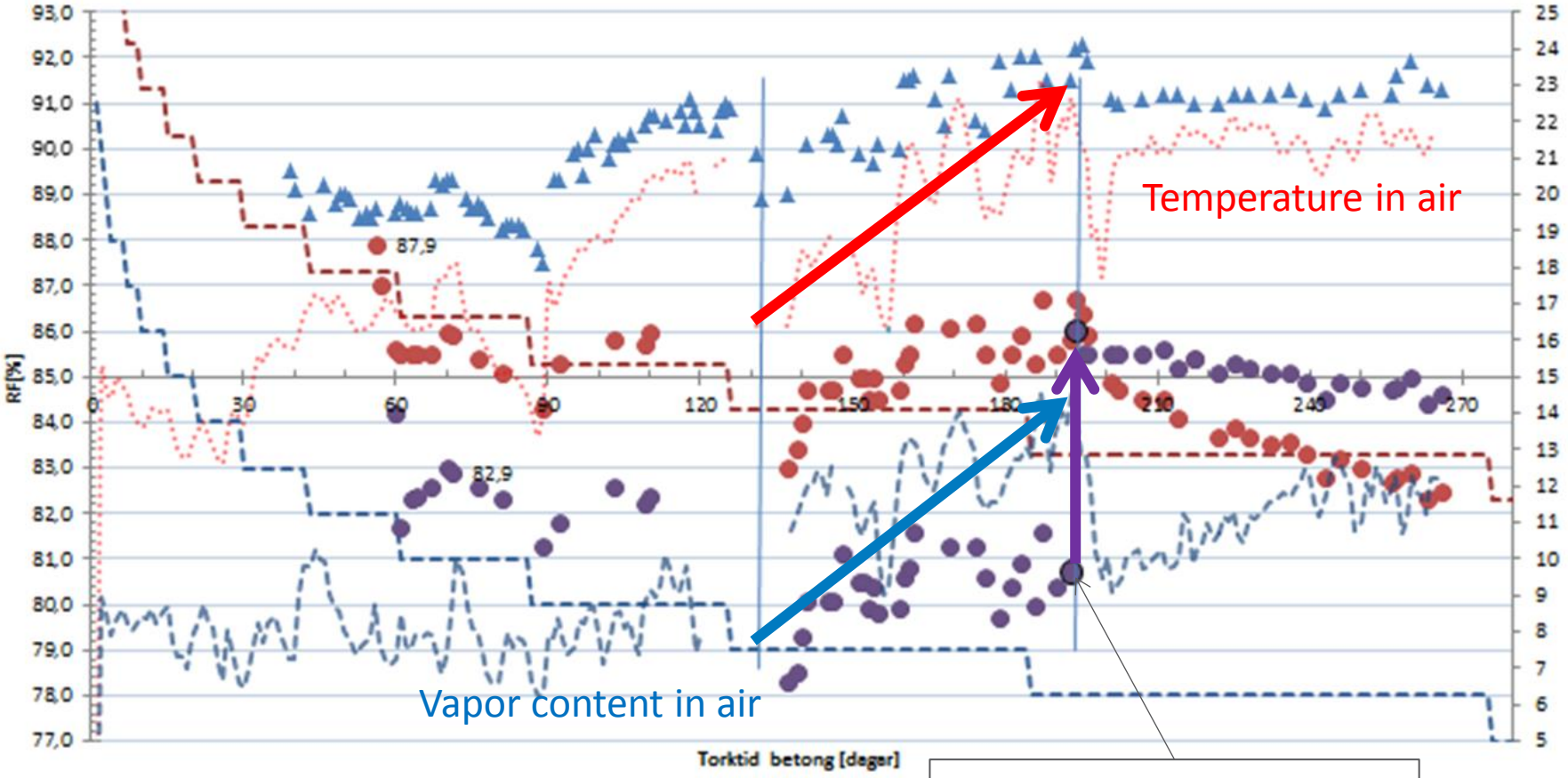
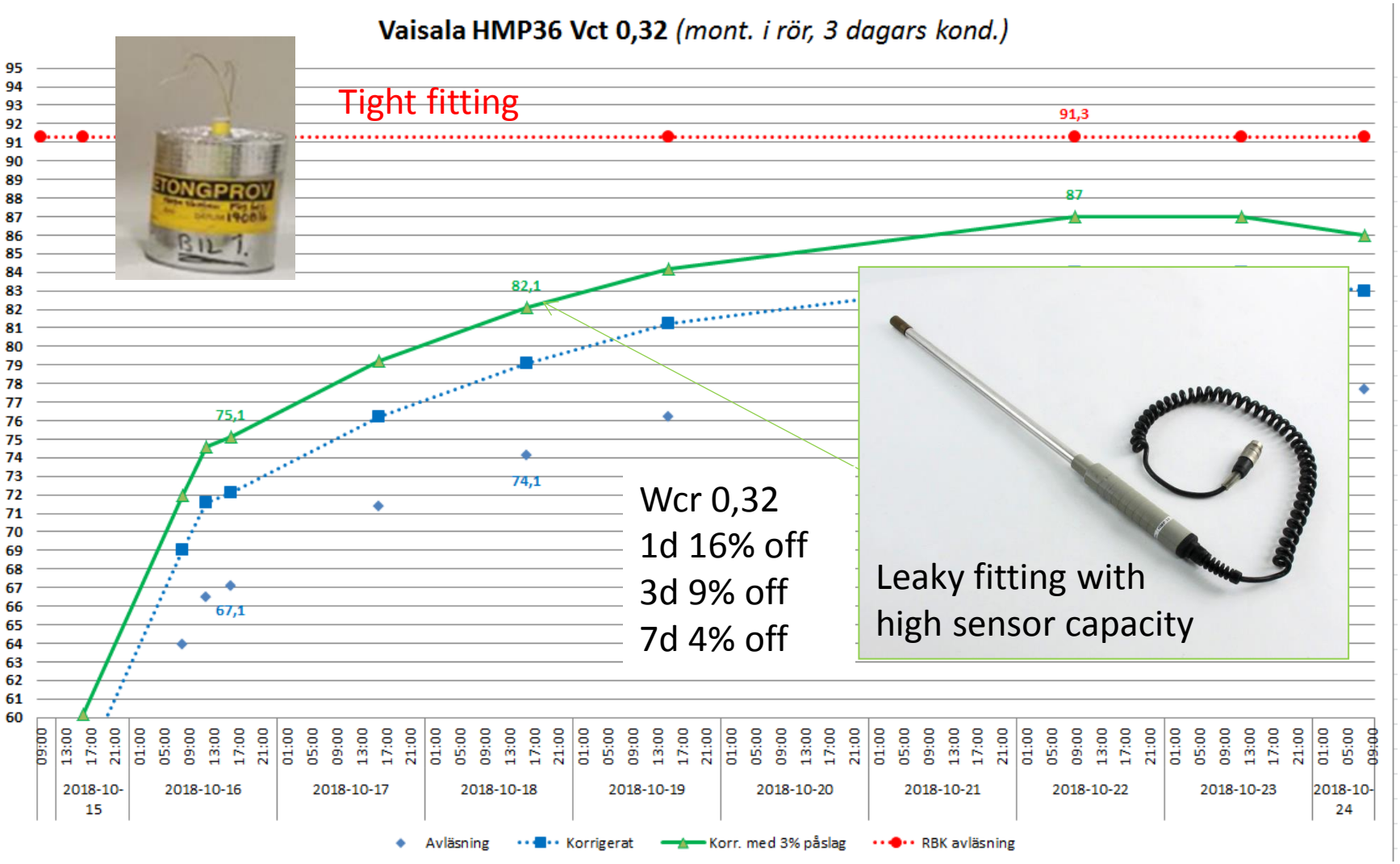
Flow balance issues will result in different readings



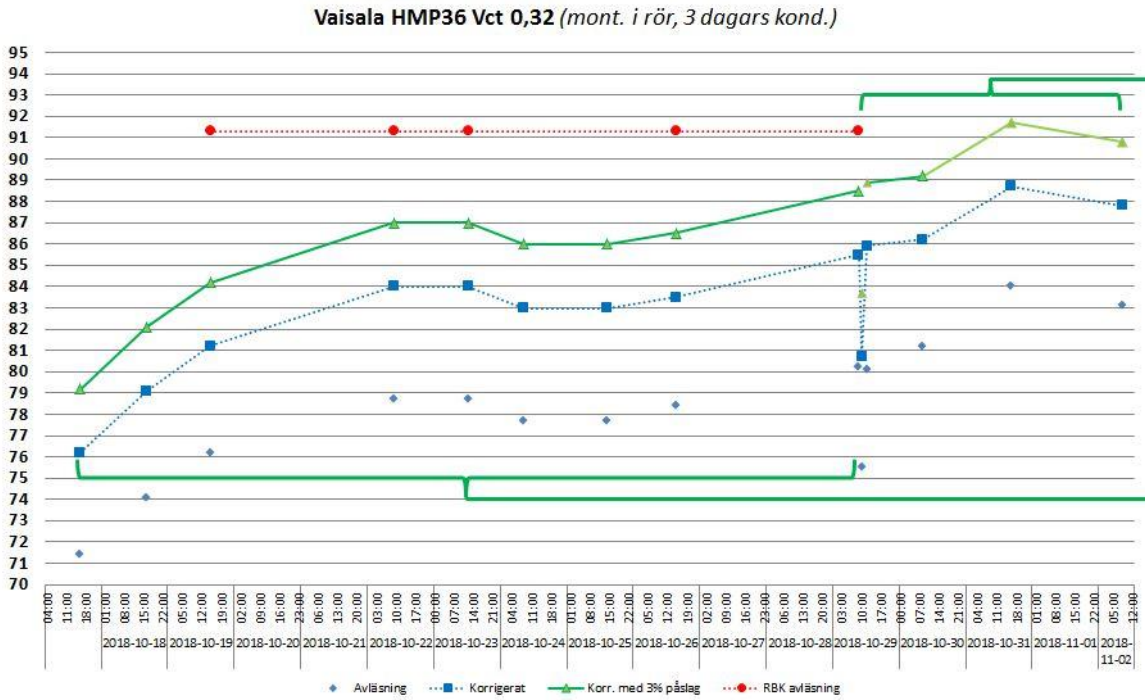
If the balance is changed after a formed drying profile in the hole we get change in readings

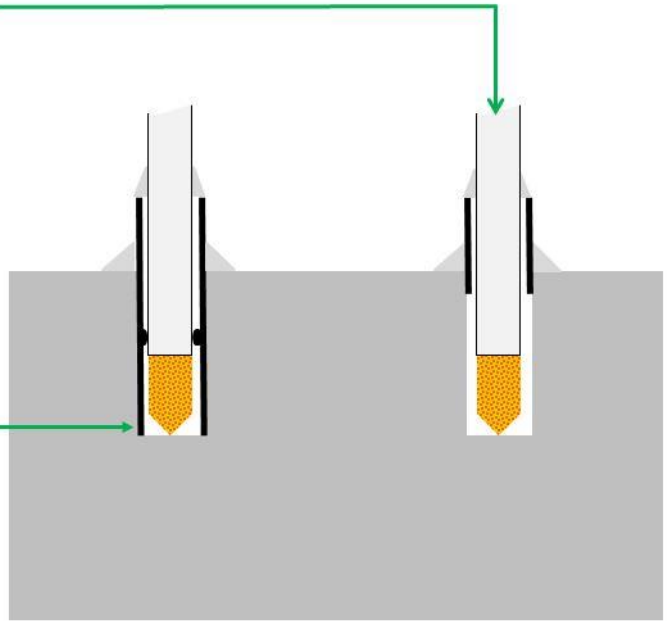


The good old days when concrete dried by itself?

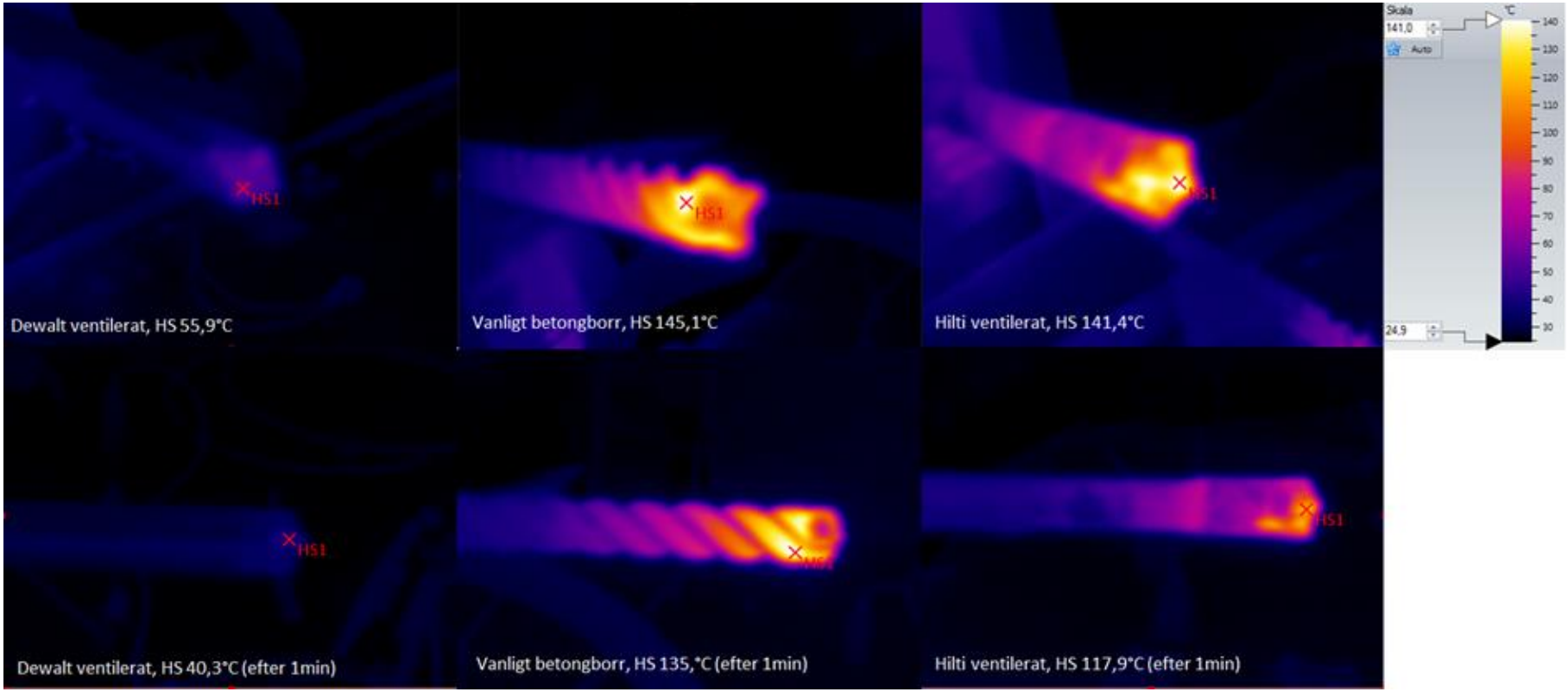


Or not?

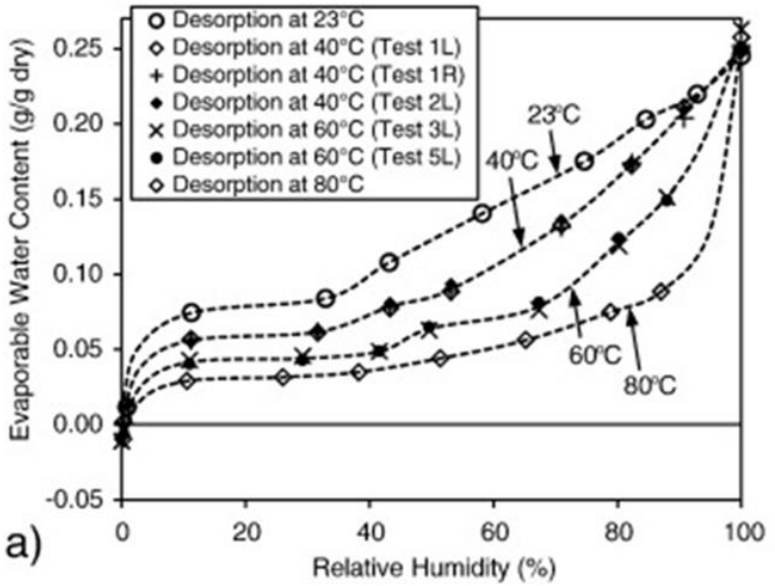


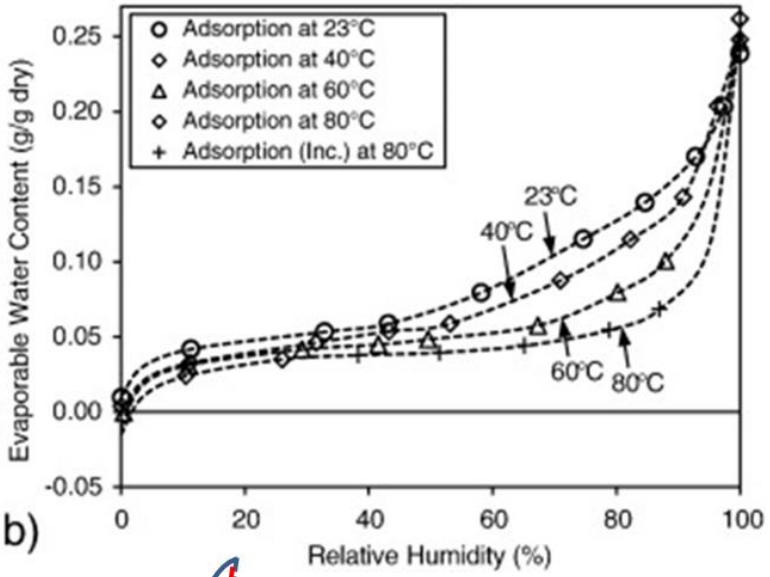


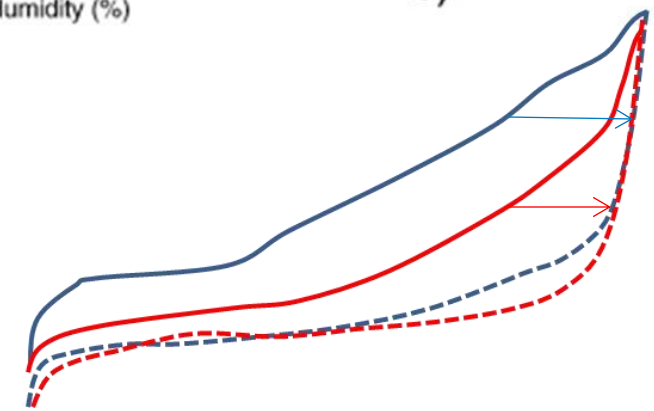
Heat effects will add issues



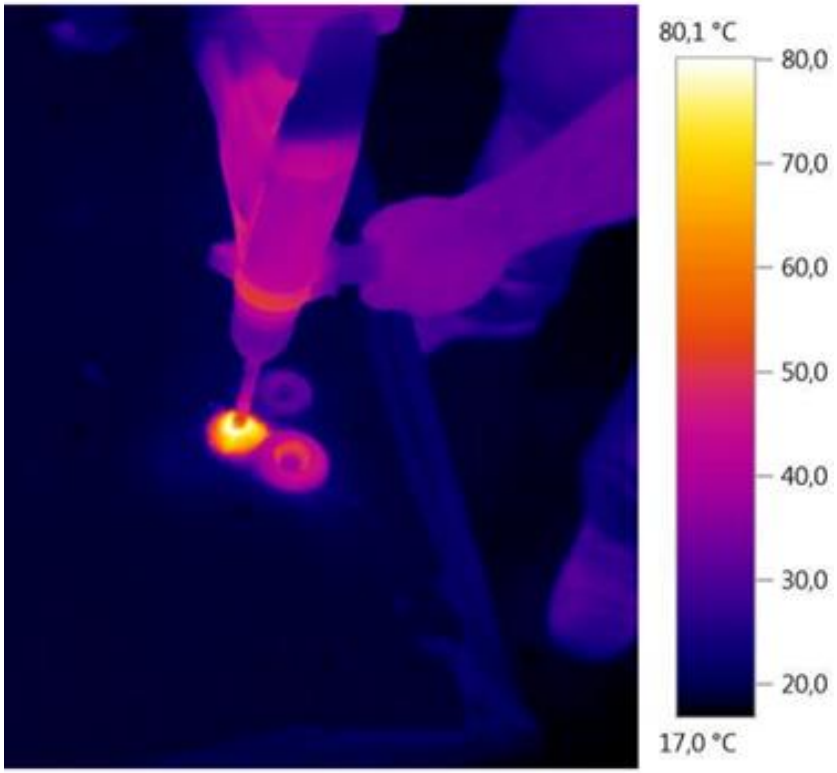
Concrete loose moisture capacity when heated (and loose vapor balance issuses?)







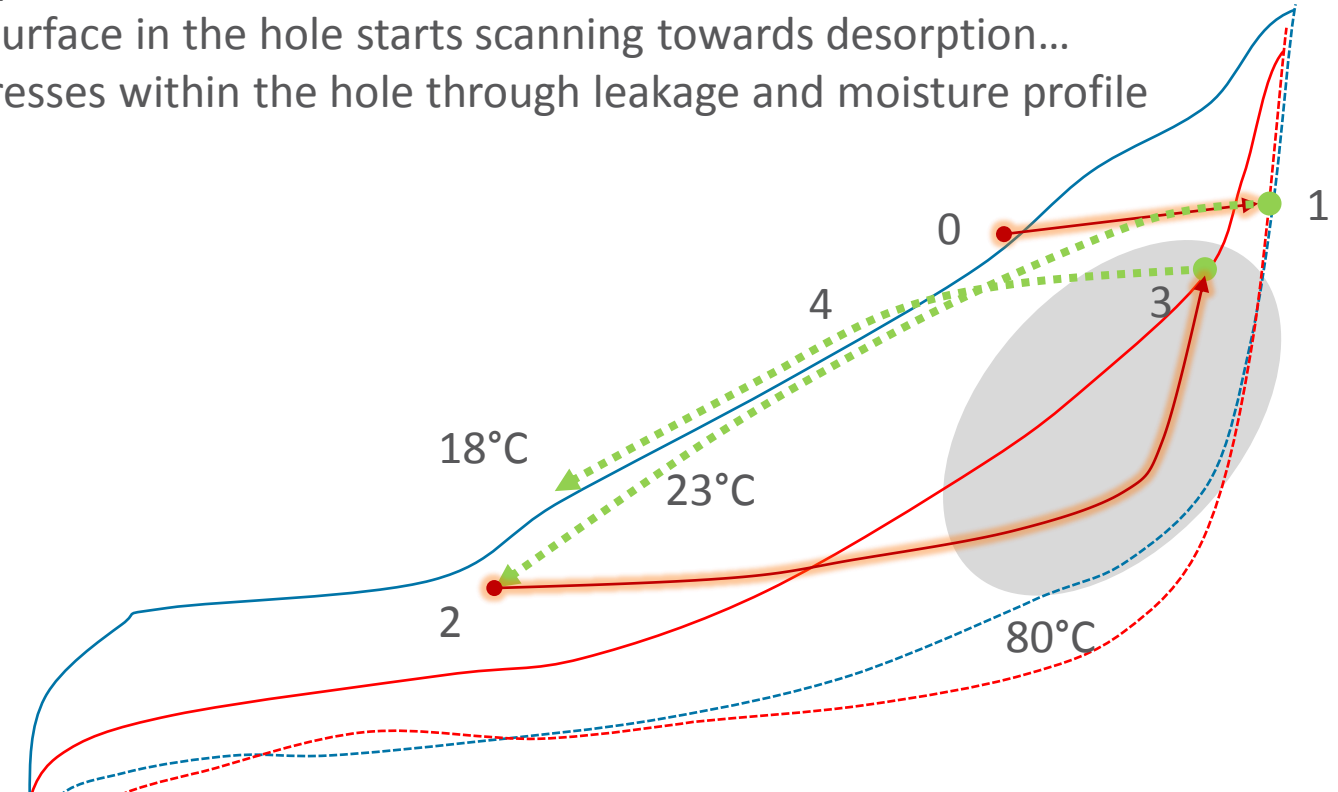
Drilling several holes in sequence (profile drilling) or deep holes will increase energy transfer. Low wcr concrete will get warmer (harder).



Depth [mm]	New drillbit [°C]	Weared drillbit [°C]
50	88	114
100	89	177
150	94	191

Heat effects when drilling without cooling

- ❑ **0-1 (appr. 30s)** Drilling (rapid heating, possibly additional moisture to holesurface from drilldust, high vapor content, steep vapor and heat profiles)
- ❑ **1-2 (1-10min)** Cleaning (rapid cooling and surface drying, recondensation in porestructure, steep vapor and heat profiles)
- ❑ **2-3 (0,1-3h)** Capped hole (surface is rewetted from within concrete, concrete is still cooling near the surface)
- ❑ **3 (3-48h)** Temperature is stable, Maximum RH is reached in most cases
- ❑ **3-4 (3h-14d)** Surface in the hole starts scanning towards desorption…
- ❑ **4** Drying progresses within the hole through leakage and moisture profile development.



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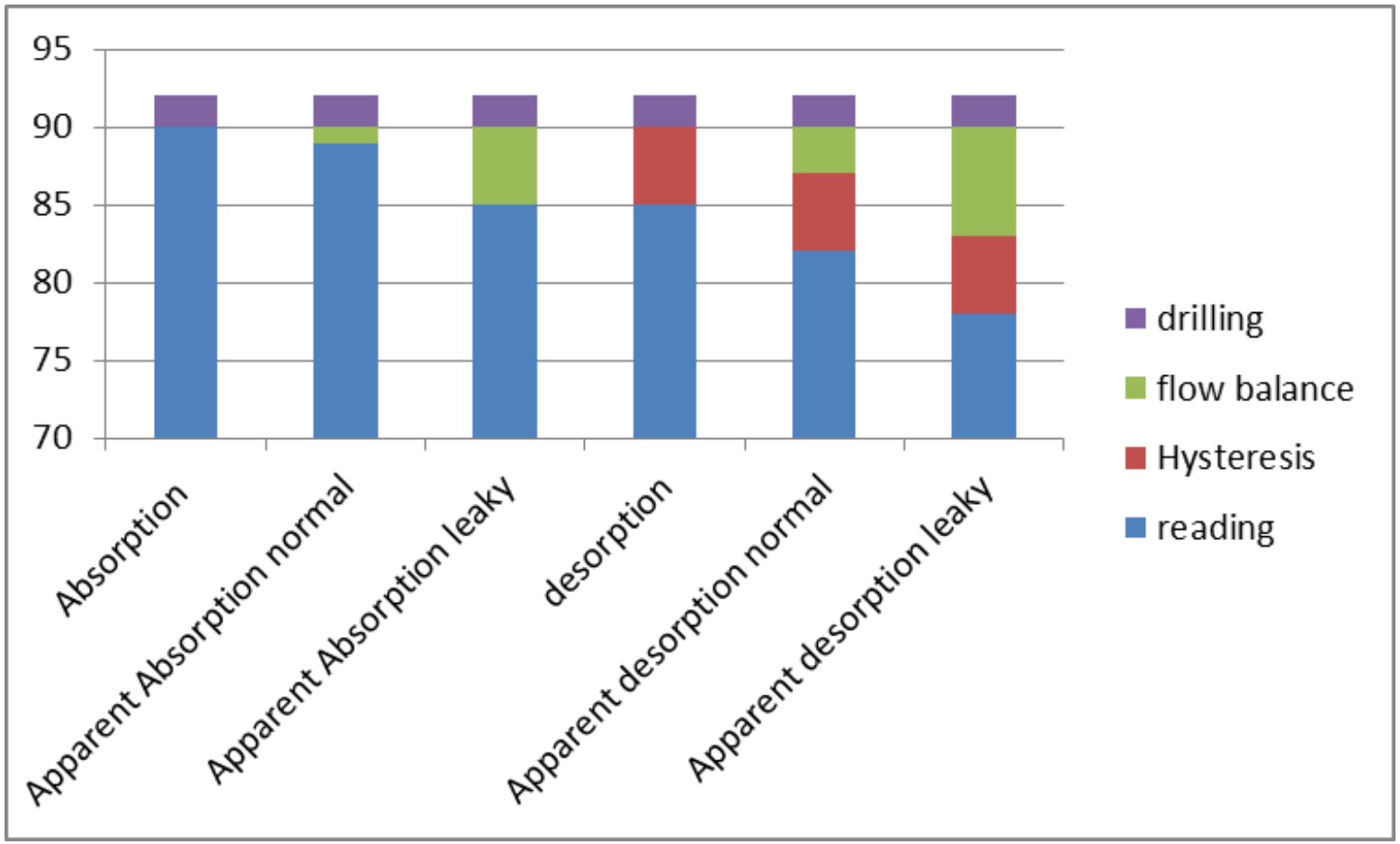
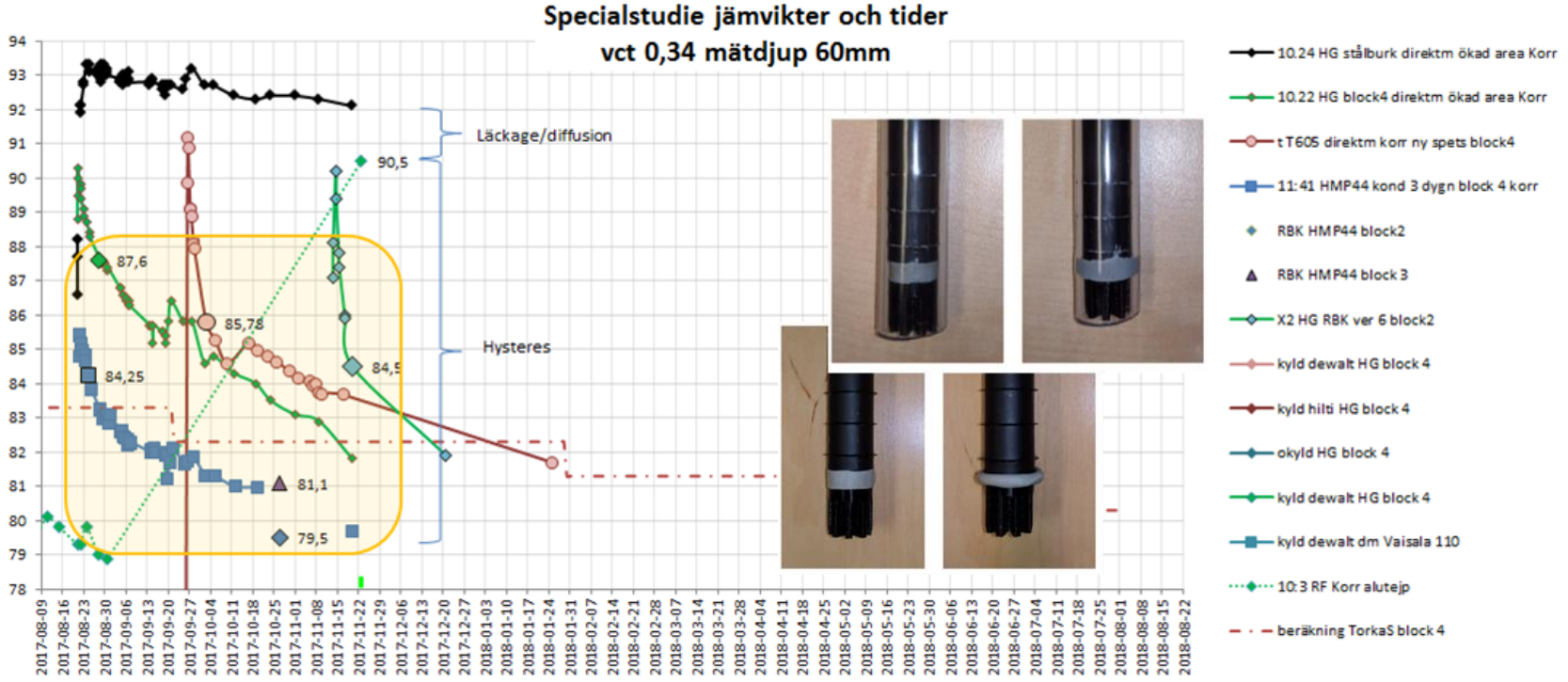
Adding heat increase early readings, possibly mainly by better flow balance (higher vapor pressure)



High early readings often described as a drill error to wait for. Compared to capped steel jars it´s probably mostly absorption reading. More exposed concrete area and improved fitting delayed desorption



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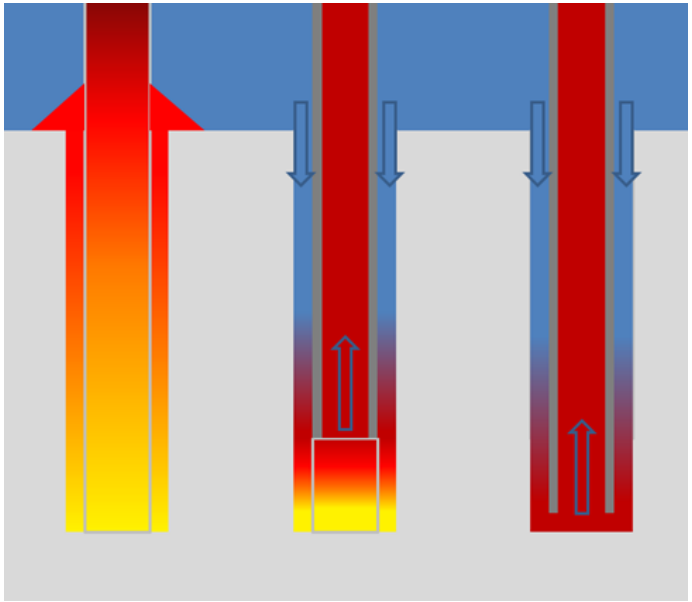
Drillbit strategy can change the intial conditions



Depth [mm]	Hilti 16mm [°C]	Hilti cooled [°C]	Dewalt cooled [°C]
60	55	34	26,8
100	59	34,8	26,2
150	65	35,2	28,1

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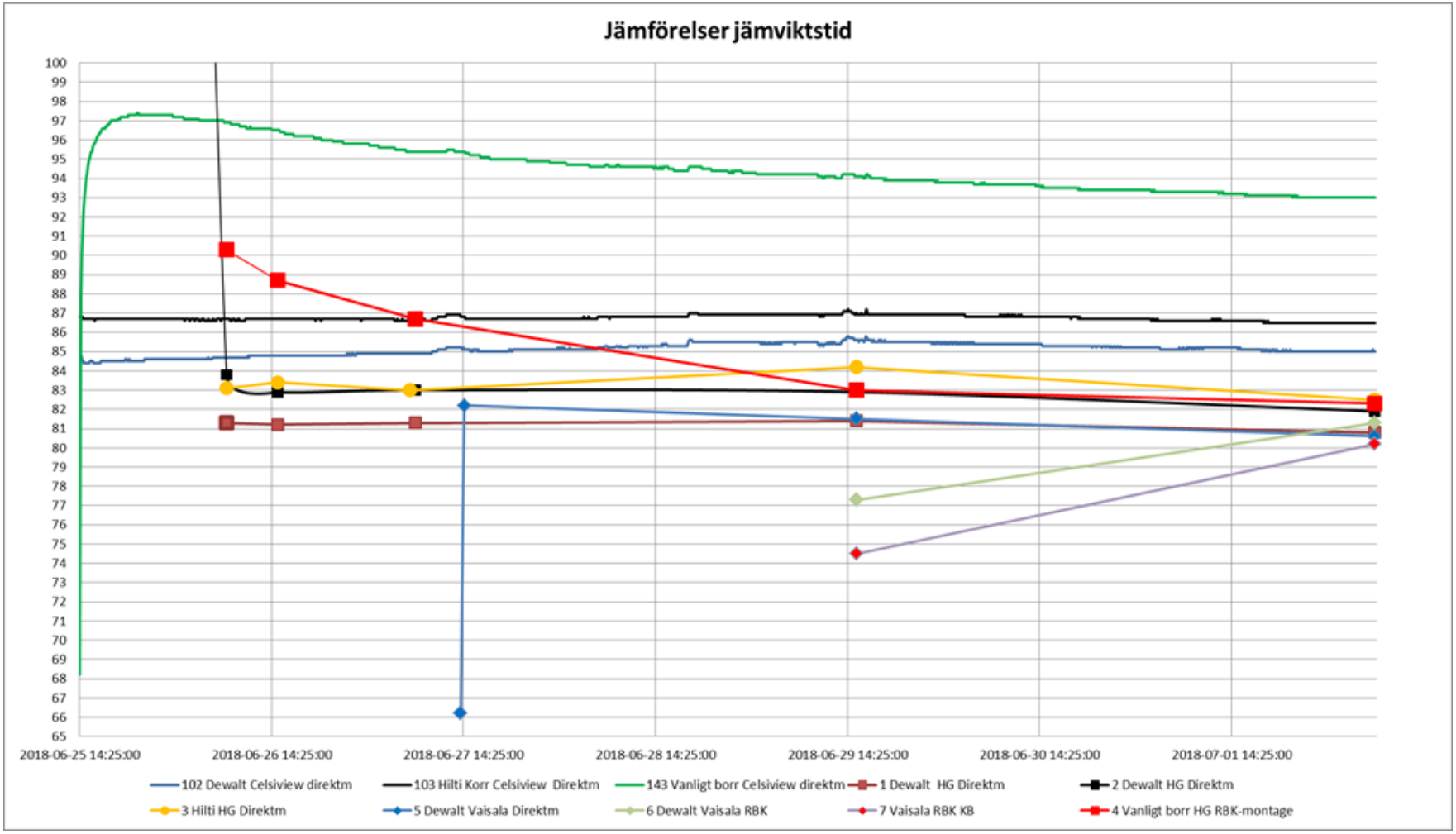
Change in behavior due to cooling and conditioning, different sensors. Early desorption.



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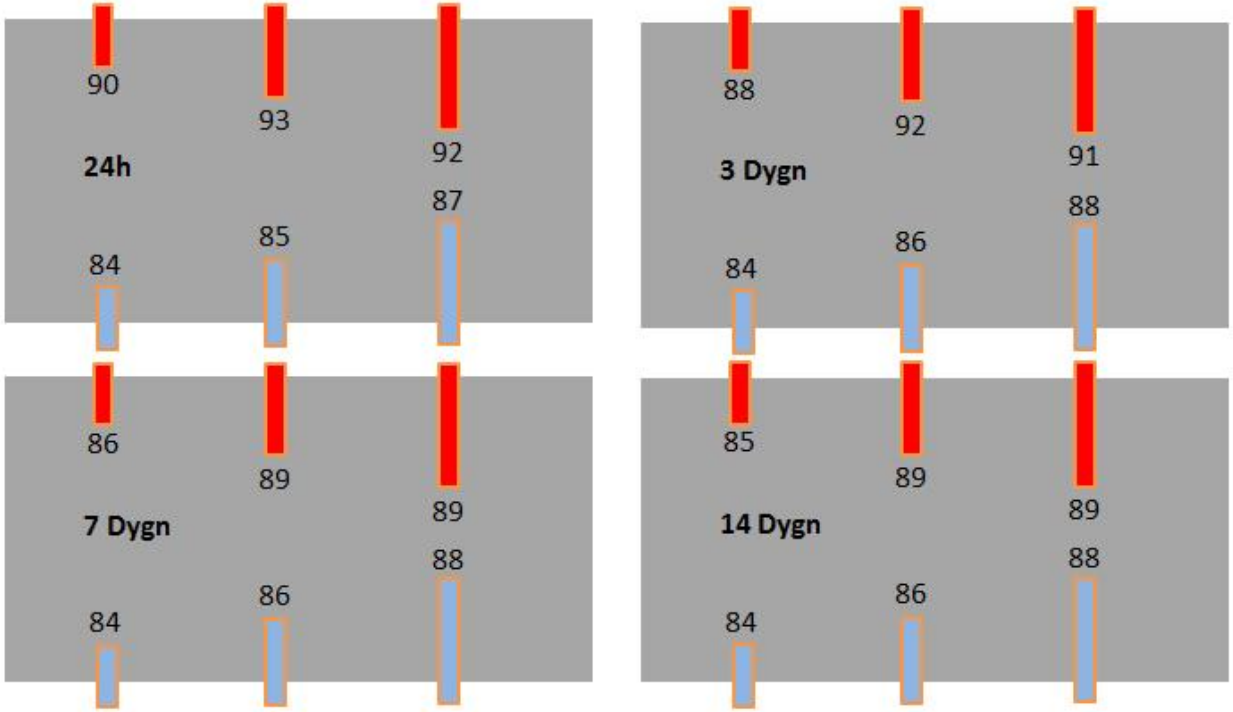
And now together!

Horizontal drilling in a testbed (sholdn´t have a profile) different drill debths 50, 100, 150mm, warm vs cooled. Debth increase exposed concrete area!

Wcr 0,34,
15% slag
1,5 years old



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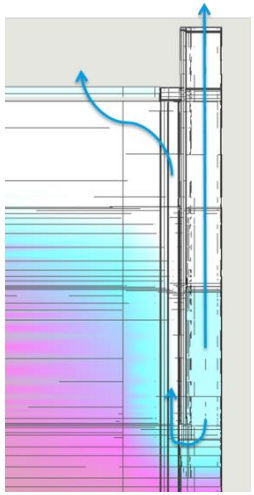
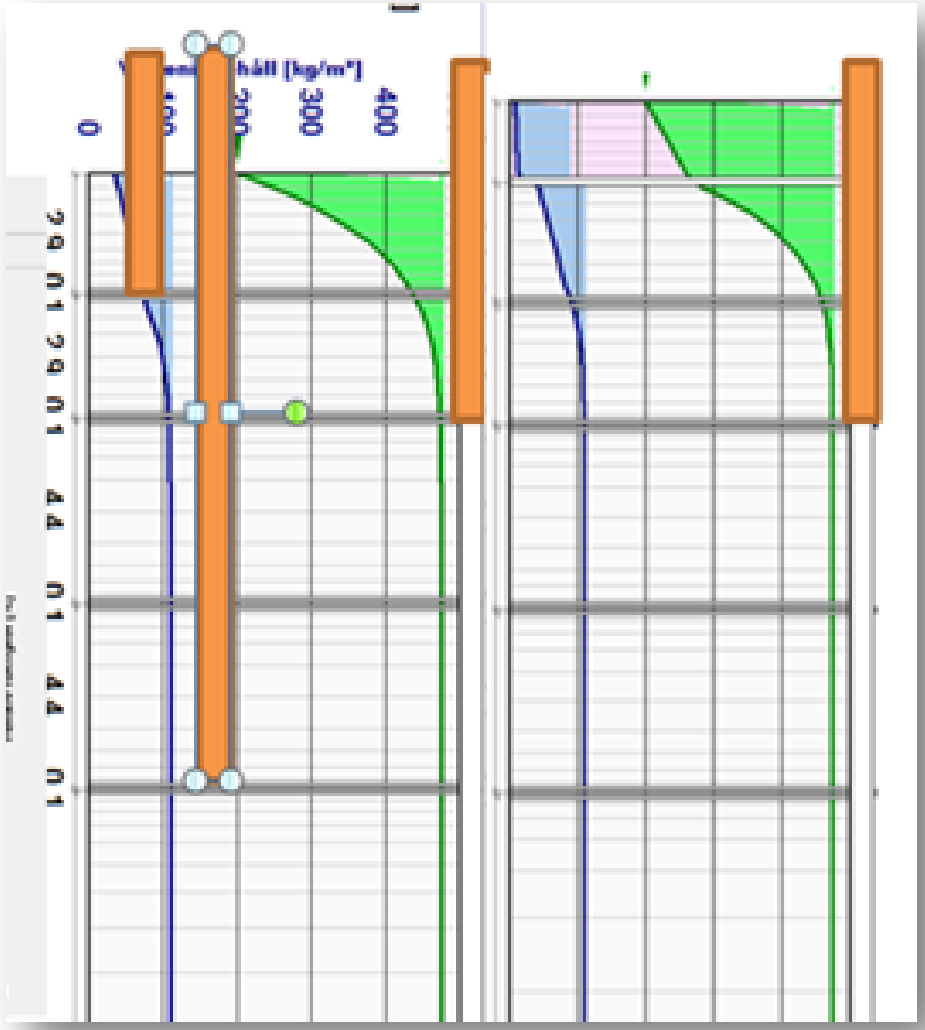
Measured is profile probably often something else than drying?





Different drilldebhts will show different vapor gradient towards the lower sleeve fitting and change the balance

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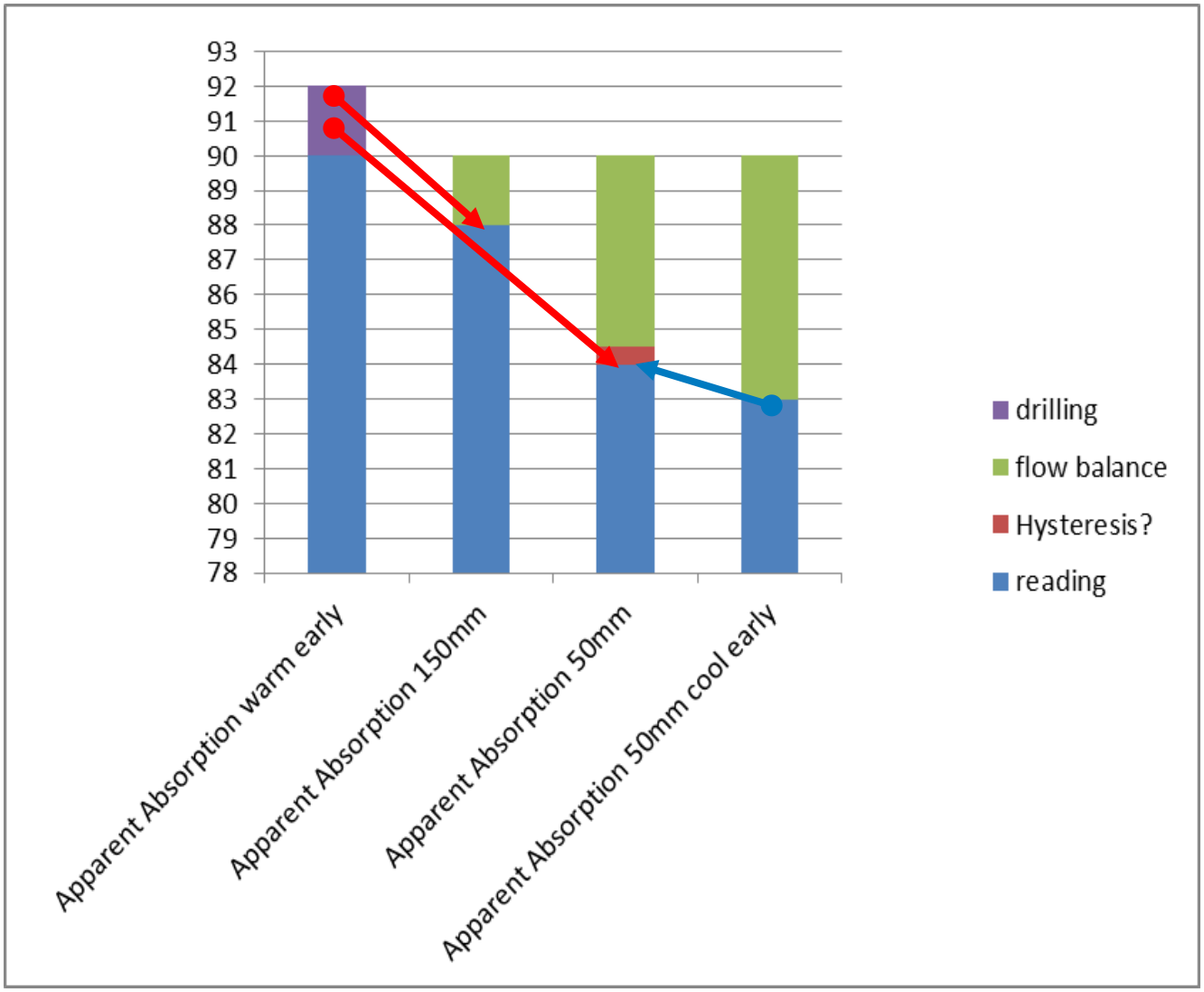
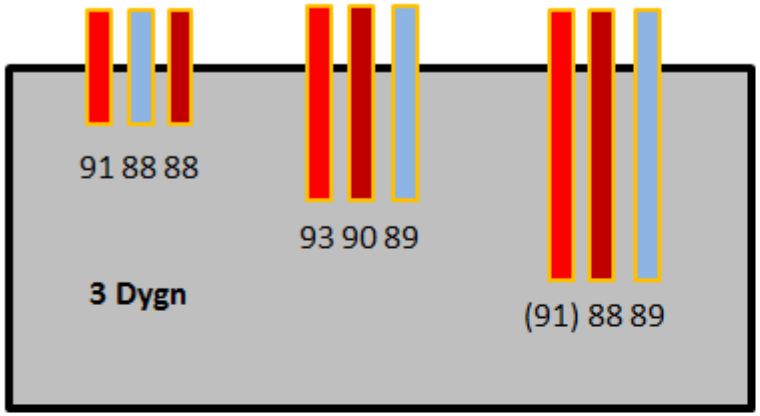
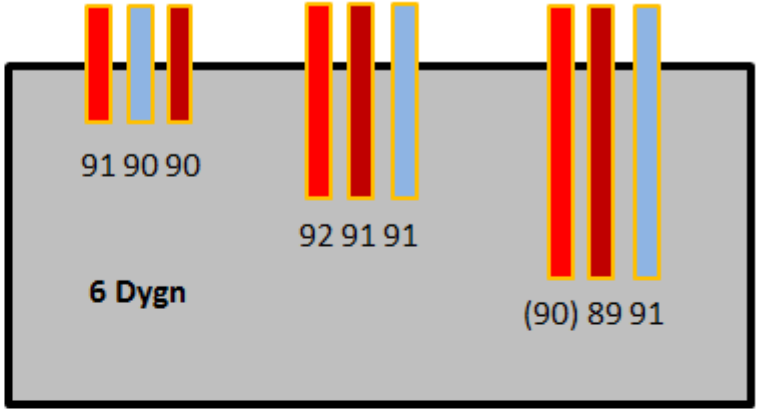
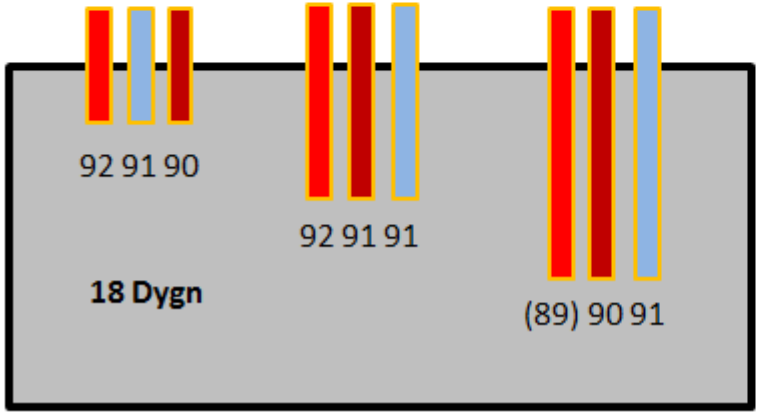
Could it be absorption readings altogether?



Old warm drilling in capped jars (dark red new sensors) vs New cooled (blue) and new varm (light red), 50, 100, 150mm drill debth.

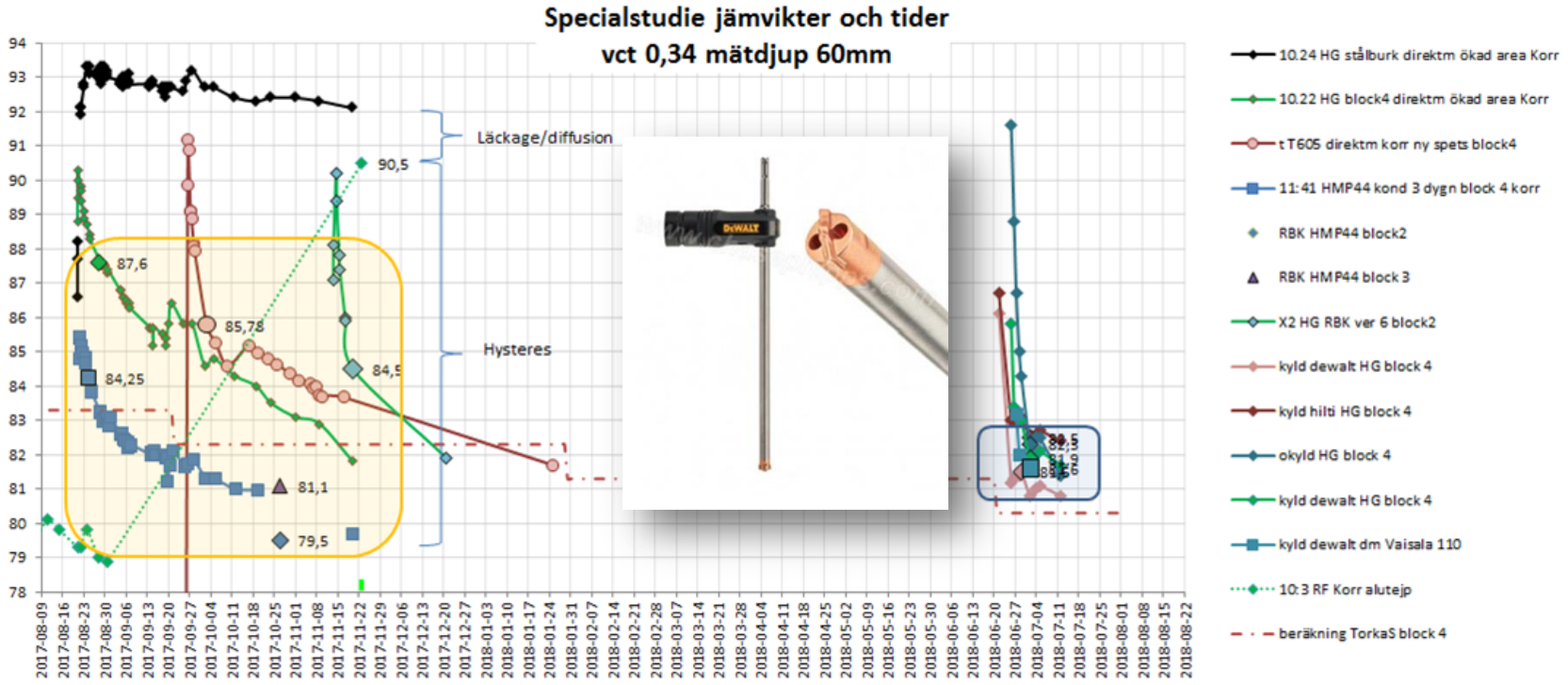






With tight sleeve fittings we get no effect from drilldebth!
( ) probably leaky

Cooled drilling without extra area is much faster to desorption readings. – extra balance error?



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Conclusions

Challenges

- Risk = absorption situations
- Moisture flow balance needs to be better explained in standards.
- Heat effects when drilling need more testing to quantify
- Temperature effects in service is not fully explained yet, underfloor heating?
- Critical moisture limits on which sorptioncurve or both? Measured how? for which temperature?
- Desorption readings need leaking sleeves. Desorption readings include very flat scanningcurves which make it harder to get repetable readings with low wcr.

Possibilities

- We can use loggers to se trends
- We can reach fast flow balance on absorption (few hours)
- We can force readings near desorption fast by cooled drilling or crushed samples.
- We could adress moisture flow more than RH.
- We can make holes without adding heat.

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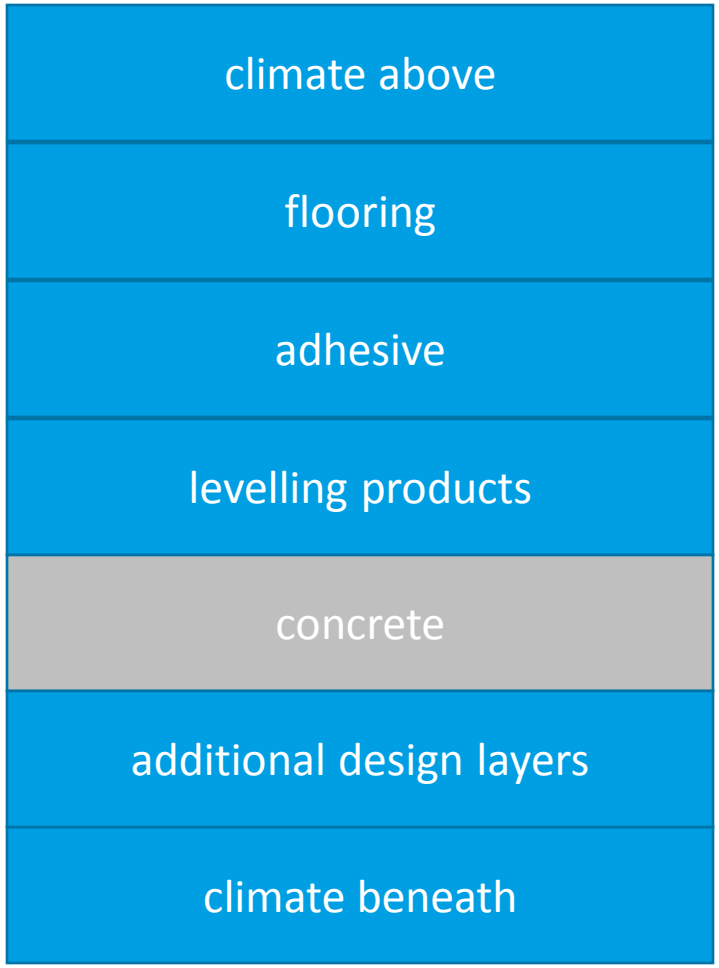
The actual risk depends on several additional factors. This is what we probably should discuss.



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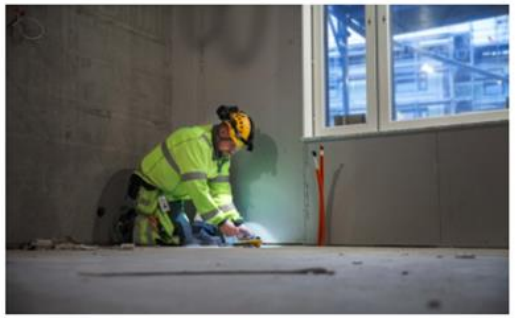
Hur påverkar fuktomfördelningen riskerna i olika golvsystem
Kan vi blockera fukten istället för att blockera bygget?

2017

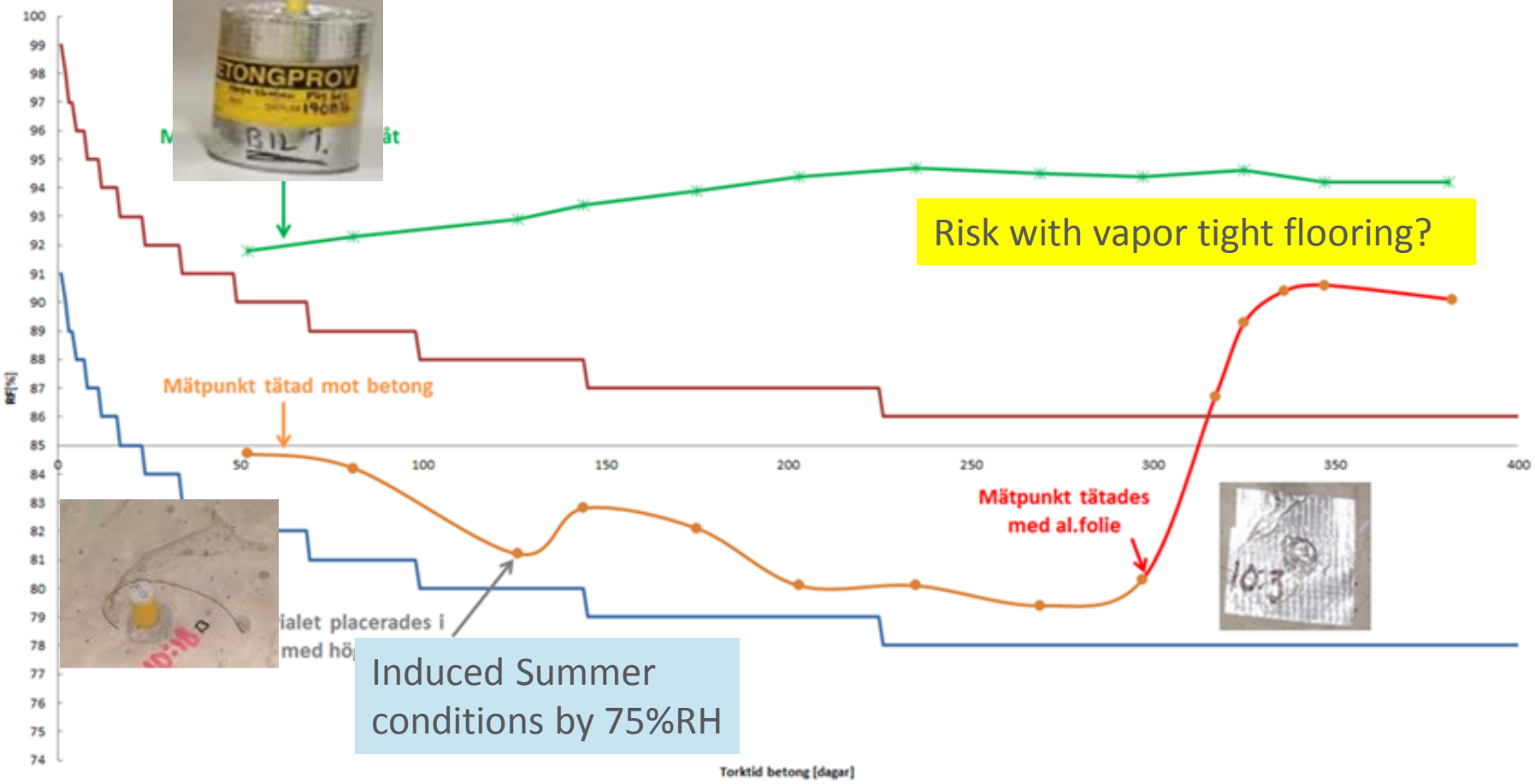
Distansmätning - var när hur?
Fuktsäkerhetsprojektera golv. Går det?
Läckande mäthål i betong
Metodval vid byggtorkning
Mikrobiella skador

2016

Fuktsäker produktion för kompakta tak med mineralull
Hållbara byggnader är fuktsäkra
Nya och gamla utmaningar med betonguttorkning och fuktmätning
Risk- och möjlighetshantering i fuktfrågor – snack eller verkstad?
Utvärdering av begränsat ventilerade vindar



And it is still interesting!



POLYGON