The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

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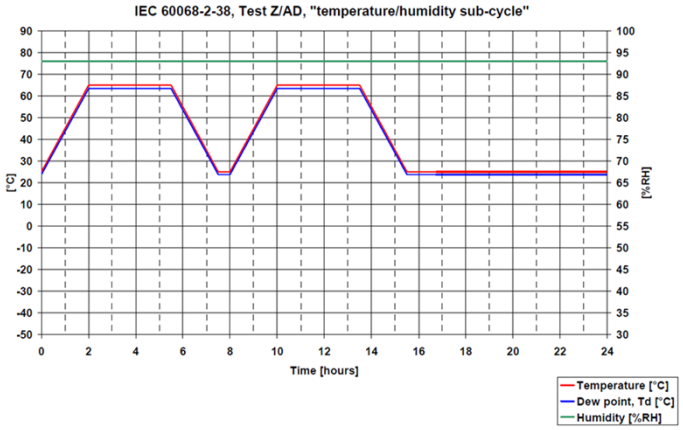



# Pitfalls when using air humidity sensors in dynamic conditions

Task 117-23647, HIT Workshop at DTI, 2018-04-10, Kim A. Schmidt, ver. 0

# Agenda

- Introduction
- Initial calibration
- Response to cyclic temperature-humidity exposure
- Response towards RH changes
- Response towards temperature and humidity changes
- Final calibration
- Summary

# Introduction


Humidity sensors will in general:

- Work OK during static conditions
- Have a risk of “strange behavior” during dynamic conditions
- Have a risk of being sensitive towards condensation

This part of the HIT project will illustrate this for 3 commercial available humidity sensors

Note that the purpose of the investigations is **NOT** to identify or benchmark “good” or “bad” humidity sensors – it’s simply just to illustrate behavior under dynamic conditions

# Investigation specimens

The selected humidity sensors should have:

- Temperature range from +10 °C to +70°C
- Humidity range from 10 % RH to 95 % RH
- Possibilities for frequent logging
- Available as commercial products on the Danish market
- High quality, but still affordable product (actual prices between approx. 1 and 2.3 k€)
- Possibilities for control of heating/purging time scheduling

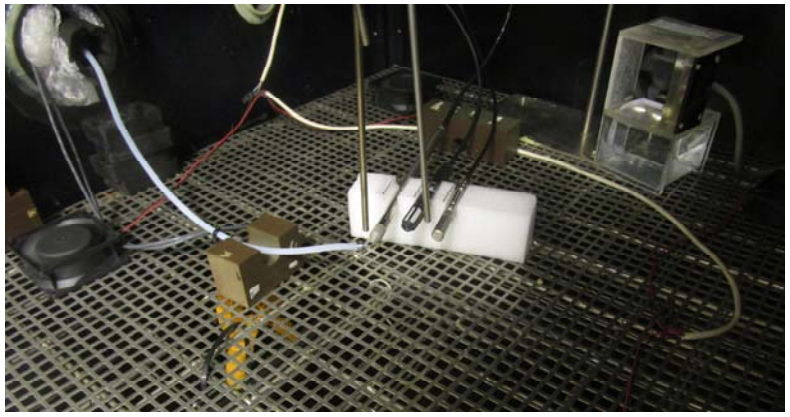
# Investigation specimens

- Rotronic HC2-S-Heated
- E+E Elektronik EE33
- Vaisala HMT337

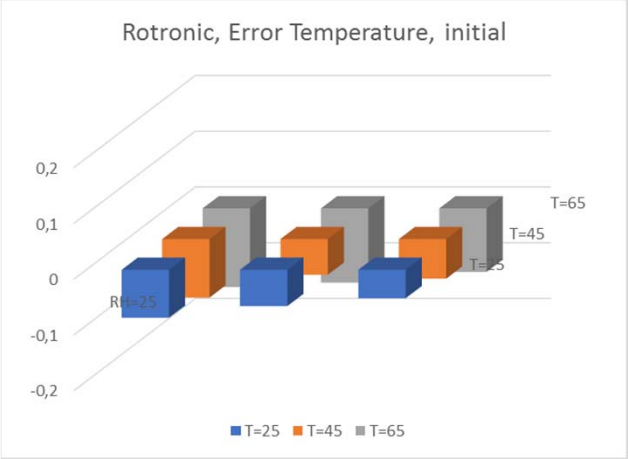
All 3 sensors used with default/typical settings.

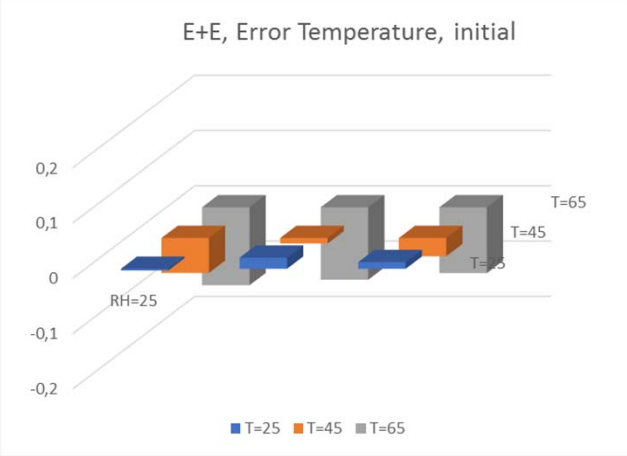

# Initial calibration

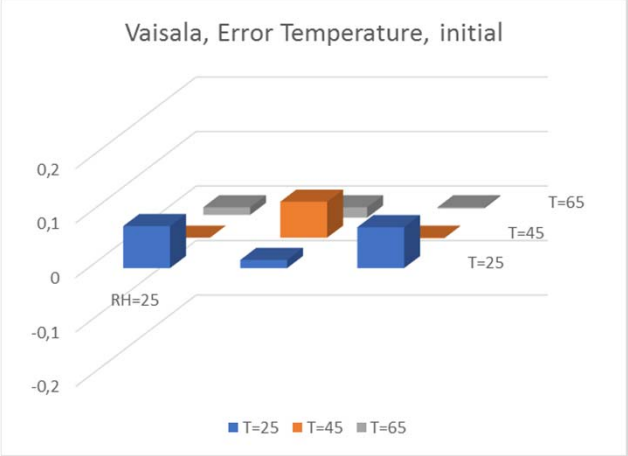
- Performed in the Danish national reference lab on air humidity @ FORCE Technology
- Reference instrument: MBW 373 ( a 67 k€ Dew Point Mirror instrument)
- @ 25, 45 and 65 deg. C
- @ 25, 60 and 95 %RH

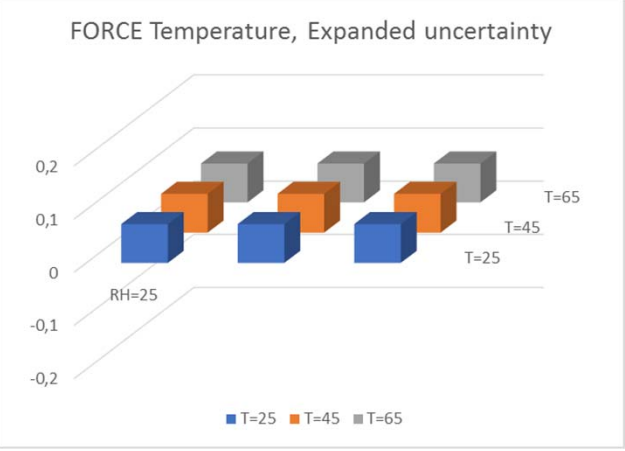


# Initial calibration – temperature error



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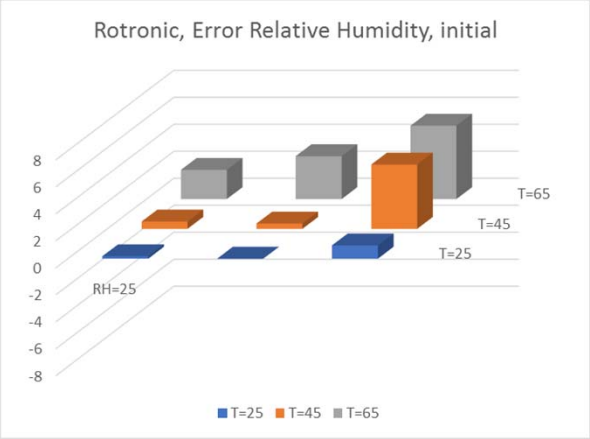
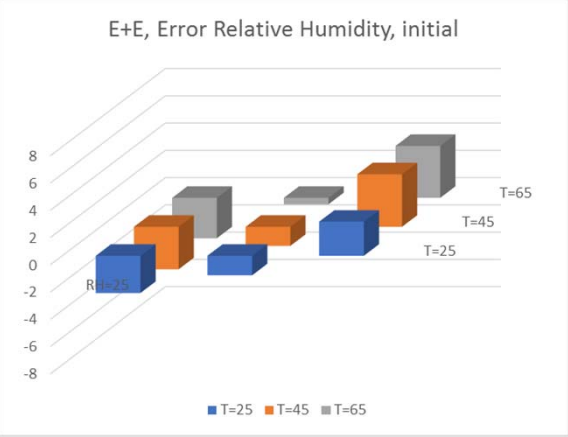
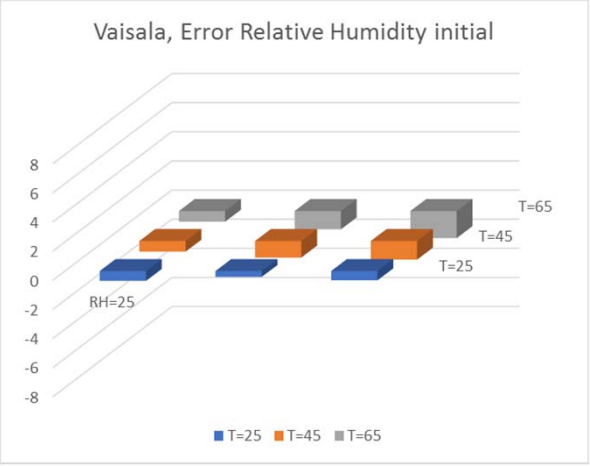
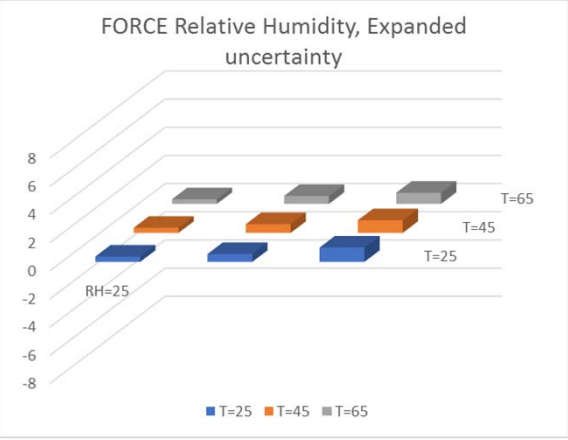


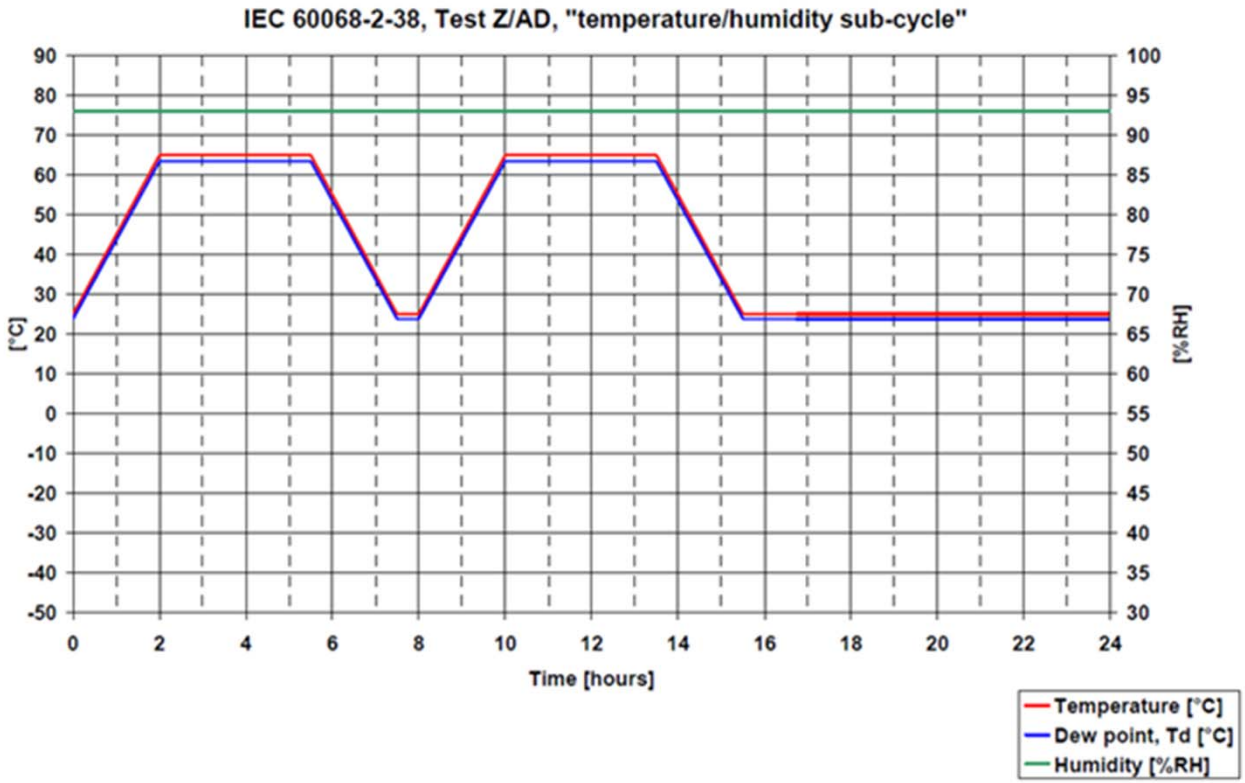



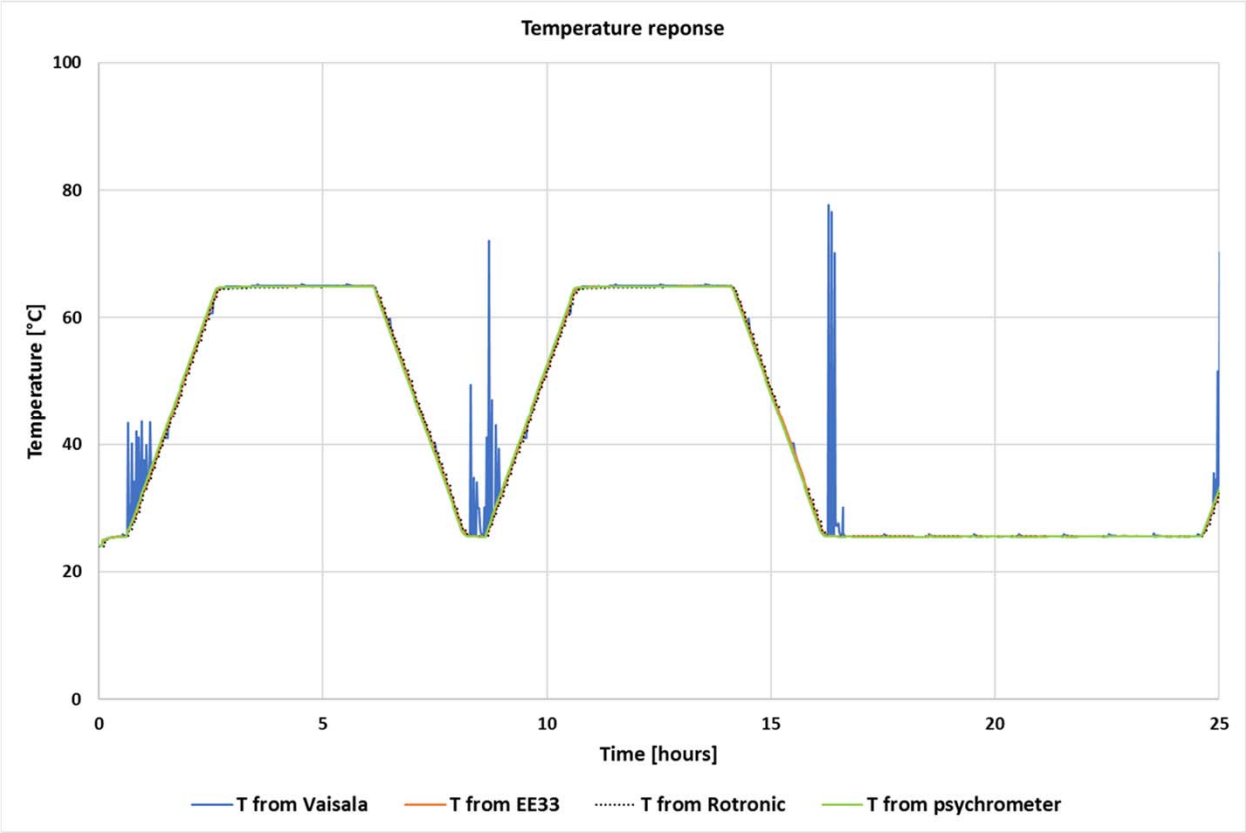
# Response to a cyclic exposure

- A cyclic exposure with constant high RH and cyclic Temperature
- Based on IEC 60068-2-38 (but without the frost cycles)
- A standard Design Verification Test of electronics for automotive applications
- 3 cycles performed
  (3 x 24 hours)

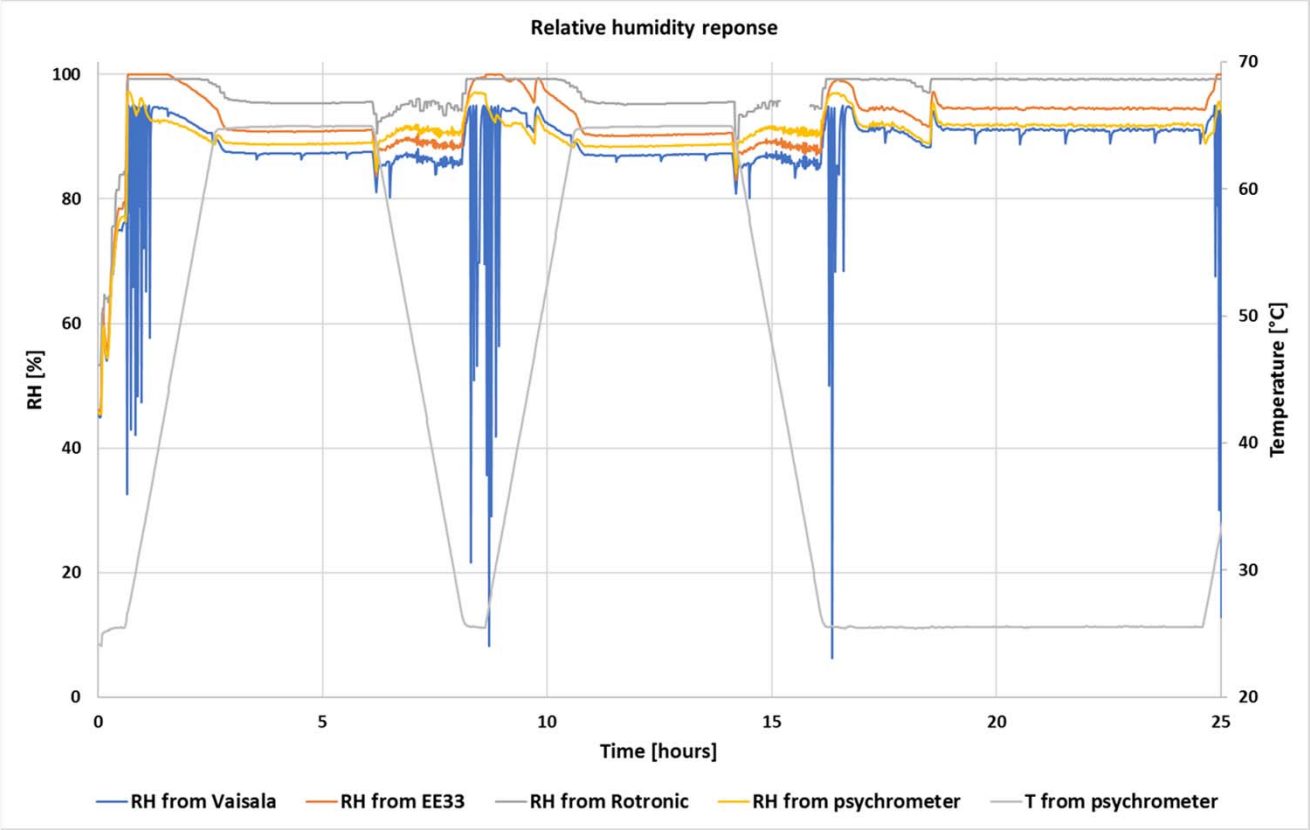
# IEC 60068-2-38, one cycle – nominal values



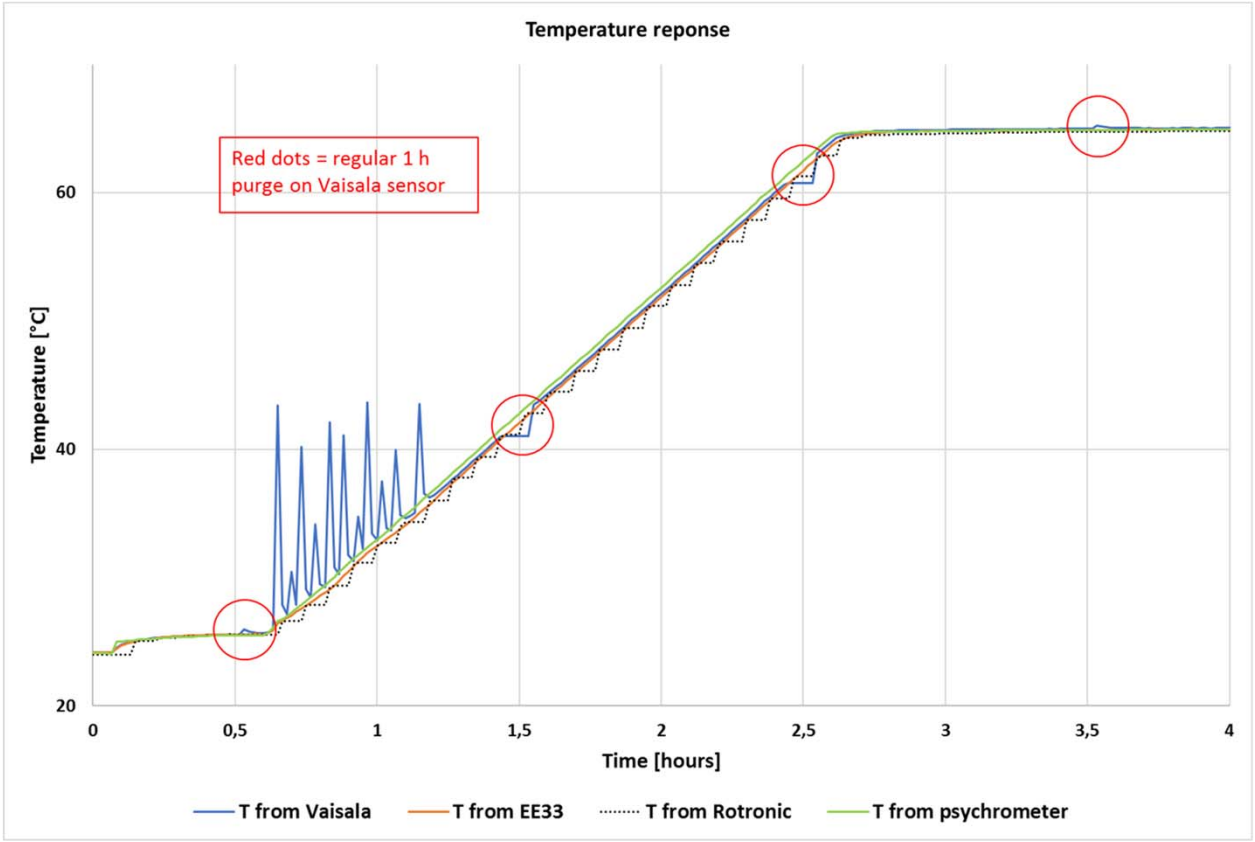
# Response to cyclic exposure, one cycle



# Response to cyclic exposure, one cycle

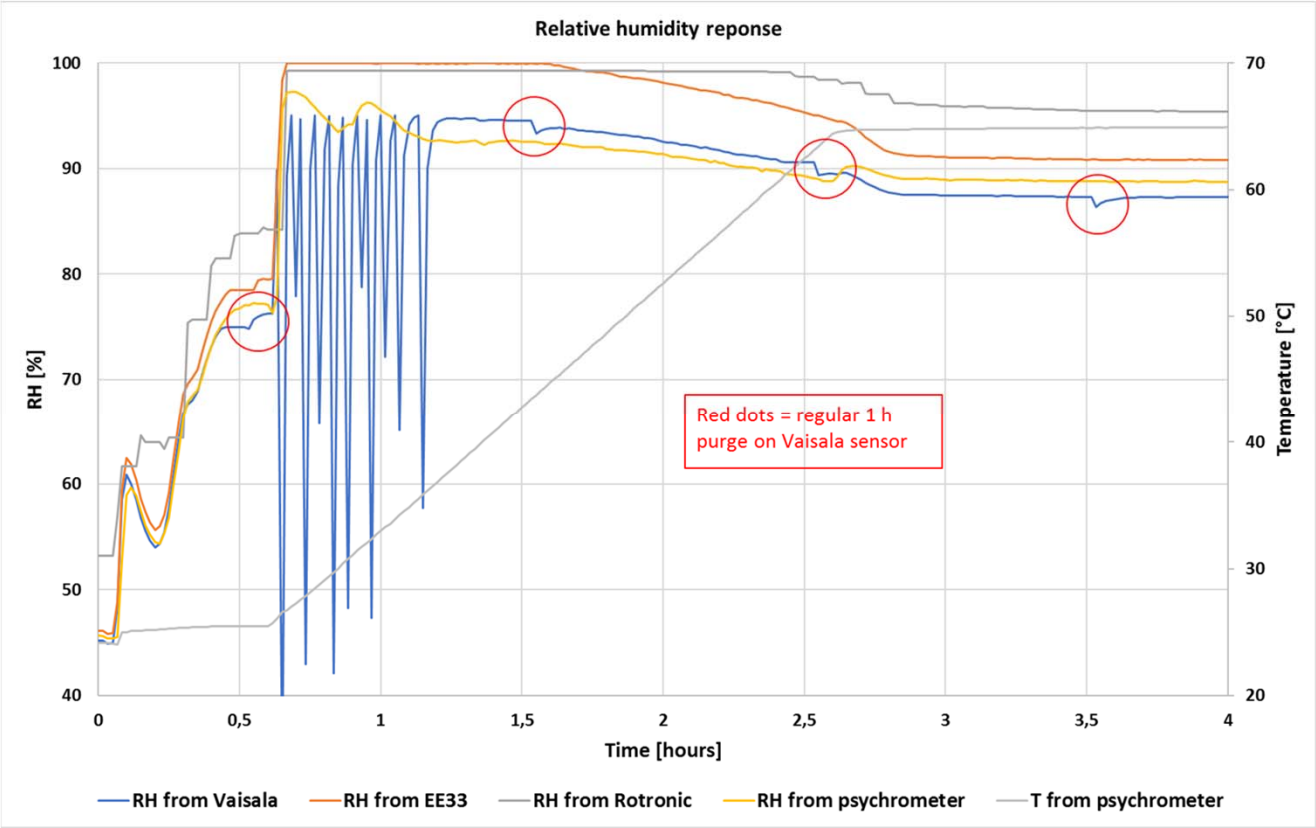


# Response to cyclic exposure, zoom on rise period




Note stepwise behaviour of Rotronic sensor

# Response to cyclic exposure, zoom on rise period



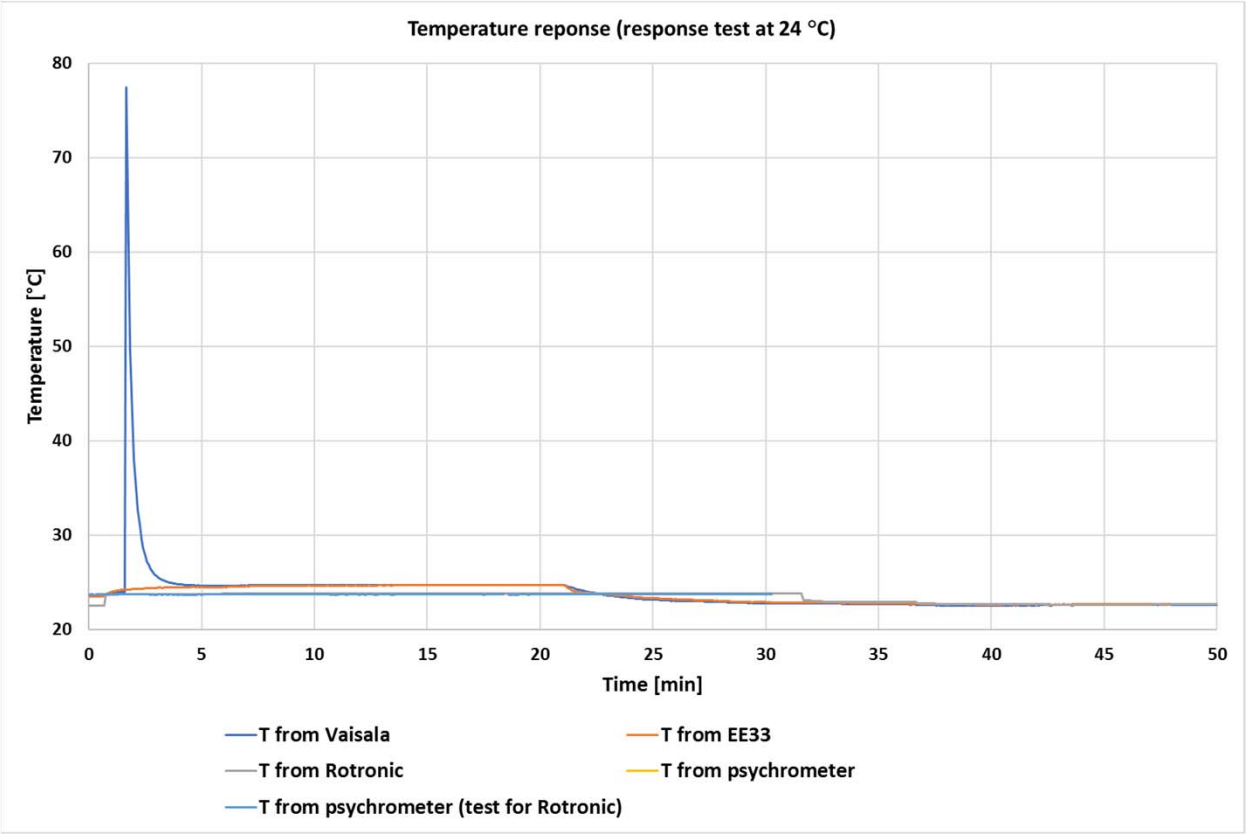
# Response to a cyclic exposure - summary

- No overall “change in measuring pattern” observed over several days (no “permanent drift”)
- “Condensation delay (saturation)” observed on Rotronic and E+E
- Vaisala generally “closest” to our psychrometer, but “fluctuating behavior” observed during periods with risk of condensation
- Rotronic: “Stepwise behavior” during “dynamic” temperature changes
- E+E: 1 h purge “not visible”

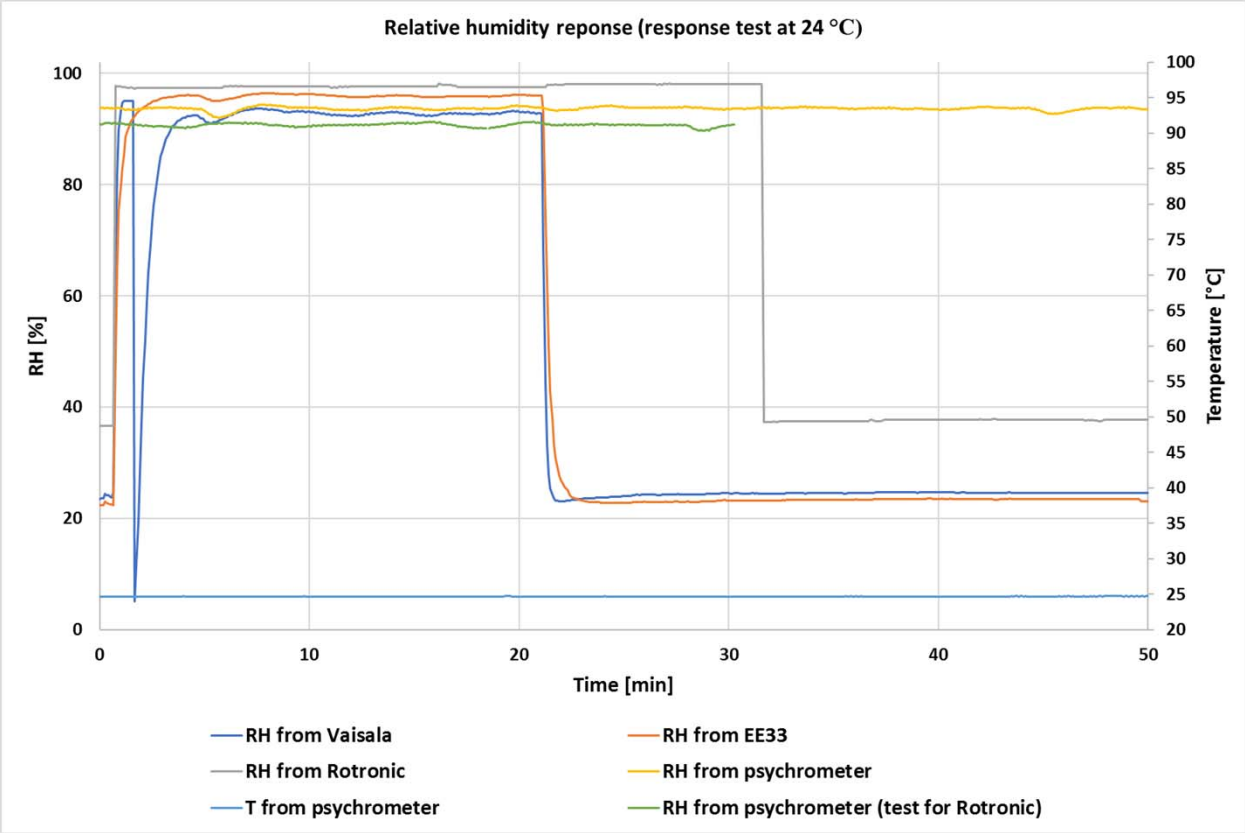
# Response toward RH changes

- Directly from normal ambient into a climatic test chamber with the same temperature but high RH, and back to ambient after stabilization of sensor outputs
- Constant temperature (nominal 24 deg. C)
- Sudden change (step) from low RH (between 20 and 40 %RH) and high RH (nominal 95 %RH) and back to low RH

# Response toward RH changes



# Response toward RH changes



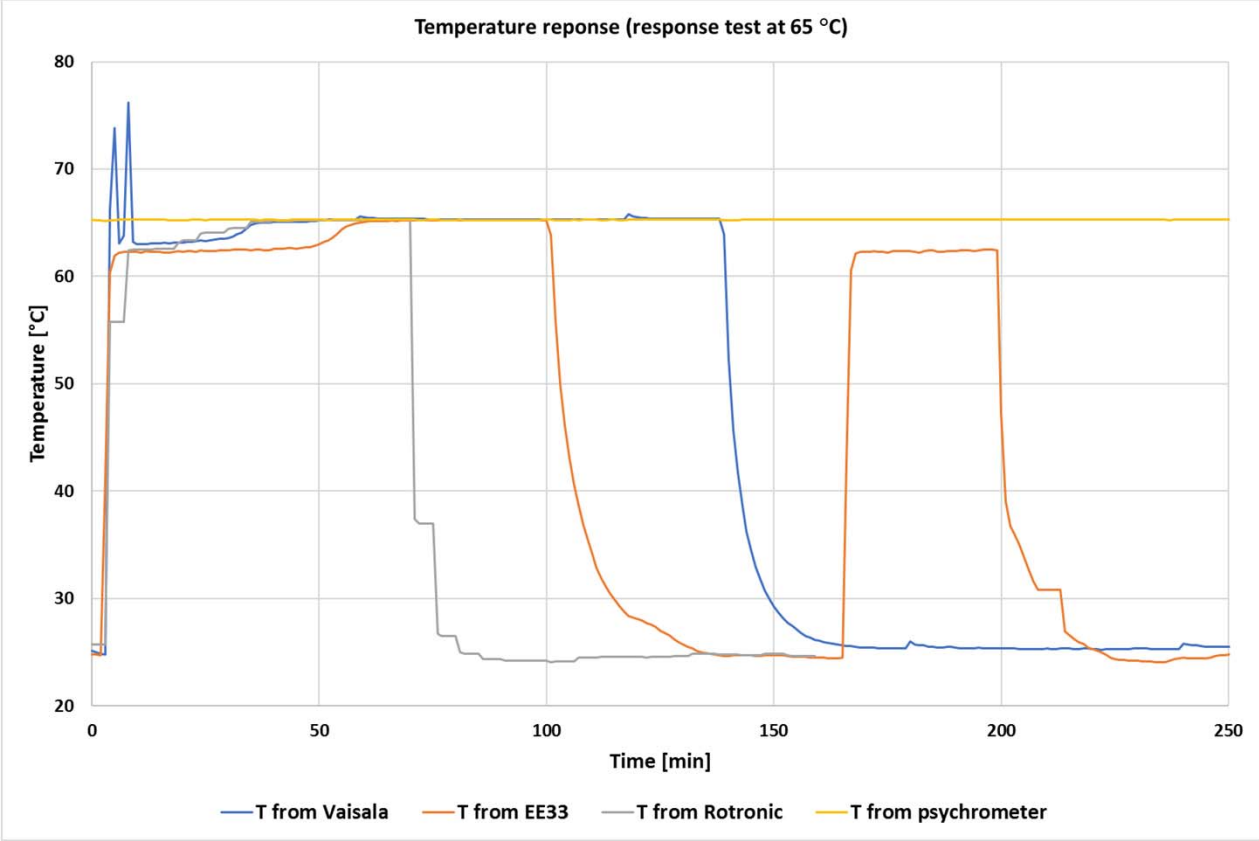
# Response toward RH changes - summary

- No “overall drift” observed
- No “condensation/saturation” issues (and none expected)
- “Fastest” response of Rotronic
- “Medium” response of Vaisala
- “Slowest” response of E+E
- Fluctuation on Vaisala response observed

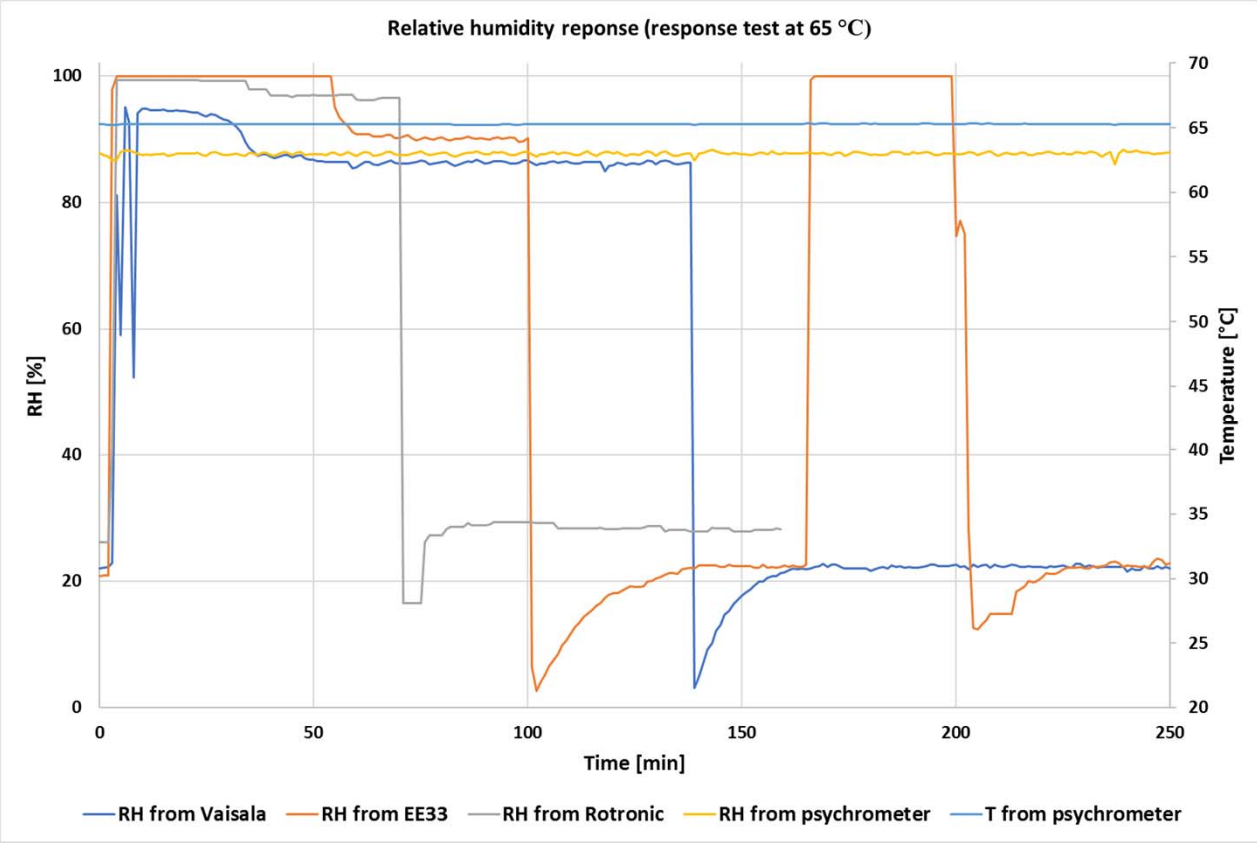
# Response toward Temperature and RH changes

- Directly from normal ambient into a climatic test chamber with a higher temperature and high RH, and back to ambient after stabilization of sensor outputs
- “Low” level: Nominal 24 deg. C and 20 – 30 %RH (ambient)
- “High” level: Nominal 65 deg. C and 90 %RH

# Response toward Temp and RH changes



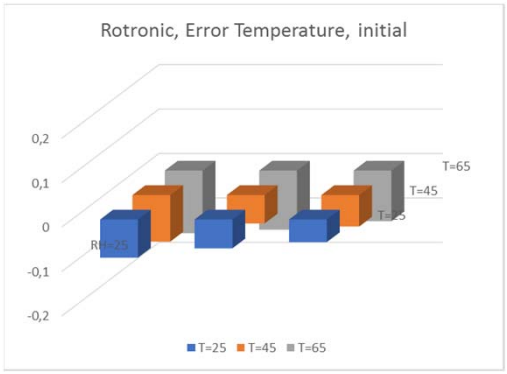
# Response toward Temp and RH changes



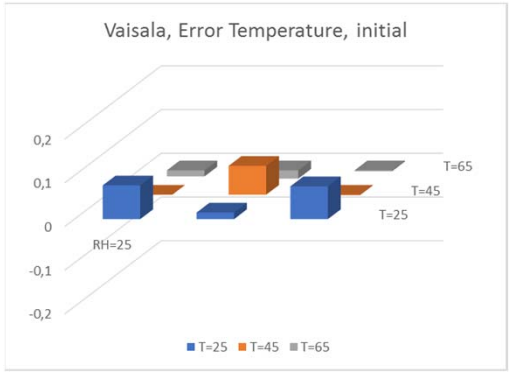
# Response toward Temp and RH changes - summary

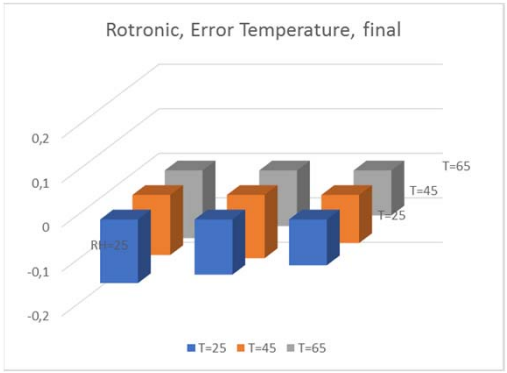
- “Delay” during rising temperature probably due to condensation
- “Condensation” issues on all 3 sensors
- “Saturation period” up to 1 h !
- “Fastest” response of Vaisala
- “Medium” response of Rotronic
- “Slowest” response of E+E
- Fluctuation on Vaisala observed
- “Humidity undershoot” on all 3 sensors (during “step down”)

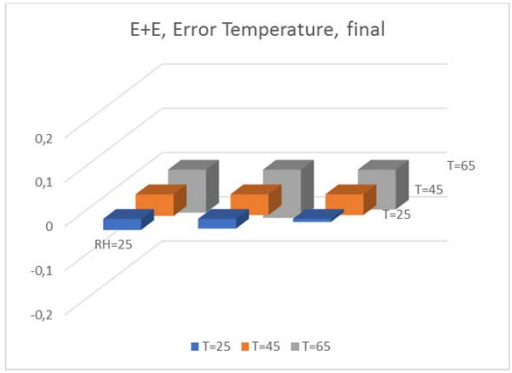
# Final calibration – temperature error

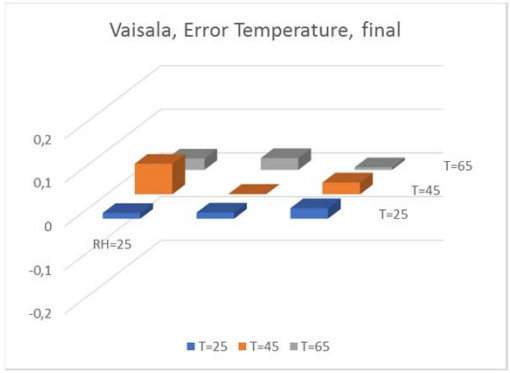




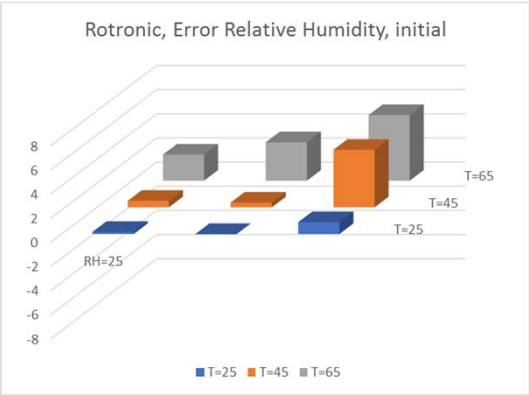


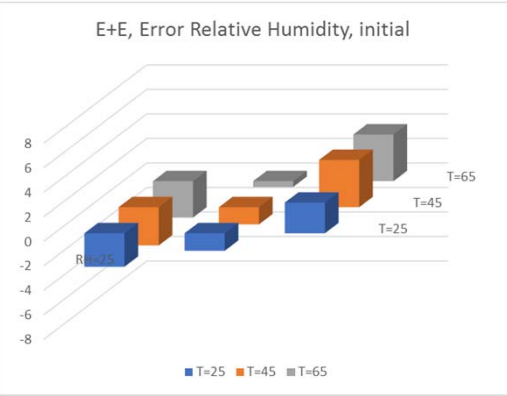



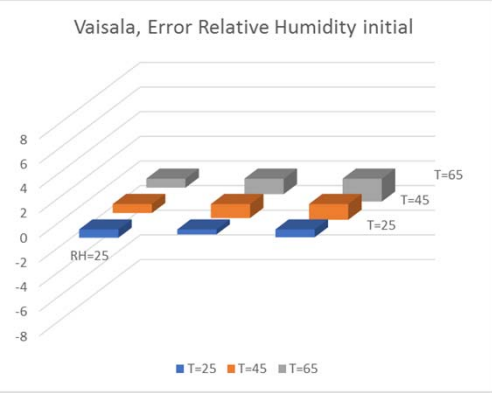



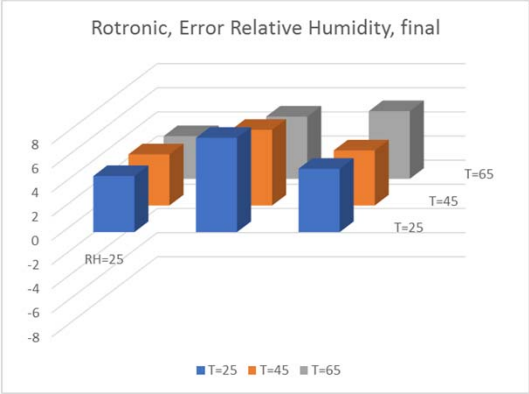



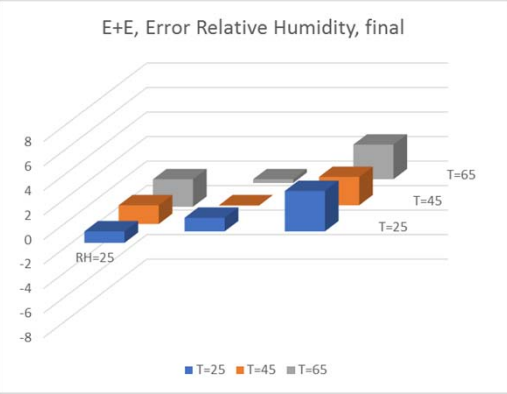
# Final calibration – humidity error

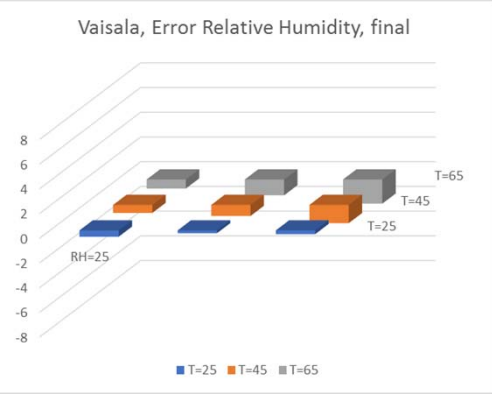


# Summary

The investigations have shown how 3 different humidity sensors will respond to dynamic conditions

These kind of responses has to be taken into account, if humidity sensors will experience dynamic conditions

This could be under intended use in a climatic test chamber or a production facility

Or it could be during un-intended conditions, where expected static conditions not could be maintained for some reason

# Note on humidity sensors and purging

Several different activities may be mentioned as “purging” in connection with humidity sensors !

One practical and pragmatic definition is:

*Any activity used to restore normal sensor behavior*

All 3 sensors are capacity based sensors which contain a polymeric material between two sensor electrodes.

All 3 sensors uses some kind of purging. Purging may be automatic and/or manual

“Chemical purge” is often “just a sensor heating process in order to get rid of un-intended chemicals absorbed in the sensor element”. And “chemicals” could also be excessive water after a situation with condensation of water on the sensor element

Further information at forcetechnology.com