Welcome!

Relative Humidity Sensor Technology

What type of sensors are in our market today?

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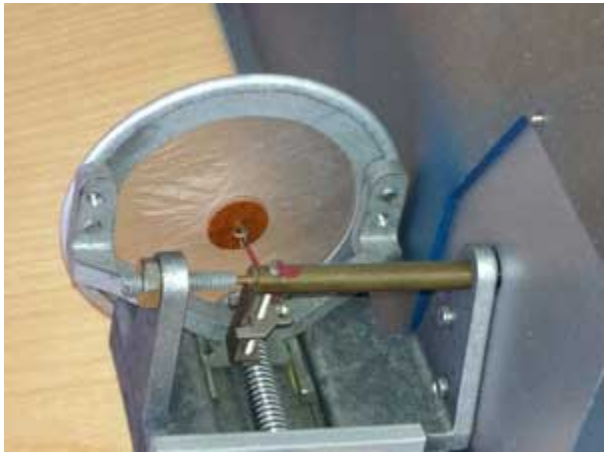
Today's Agenda

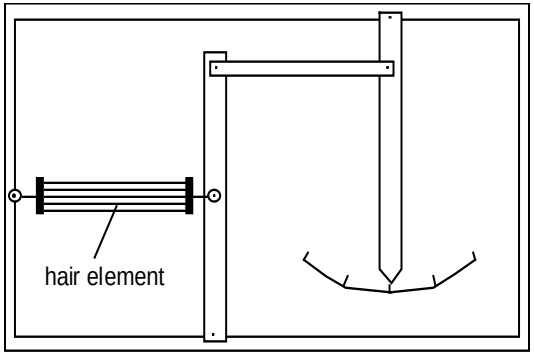
1. Mechanical
   - Displacement Sensor
   - Sling Psycrometer
2. Electrical
   - Bulk Polymer Resistive Sensor
   - Capacitive Sensor
3. Dewpoint/Frostpoint Temperature Sensor
   - Aluminum Oxide Dewpoint Sensor
   - Chilled Mirror
4. What else do you have to consider when choosing a sensor?

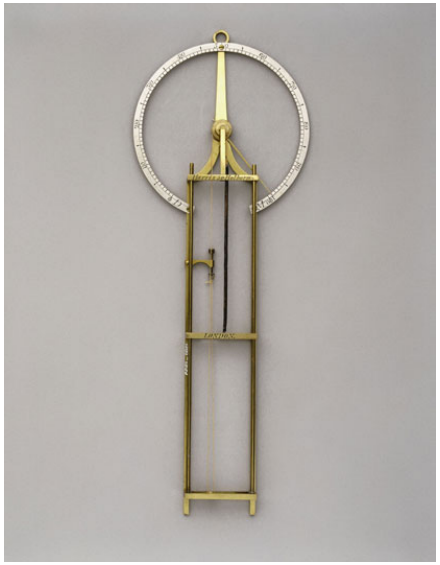
Mechanical

Perhaps the oldest type of RH sensor still in use is the displacement sensor. These devices use a strain gauge or other mechanism to measure expansion or contraction of a material in proportion to changes in relative humidity.

Common material: horse hair, human hair, catgut, goldbeater's skin, textile, or plastic







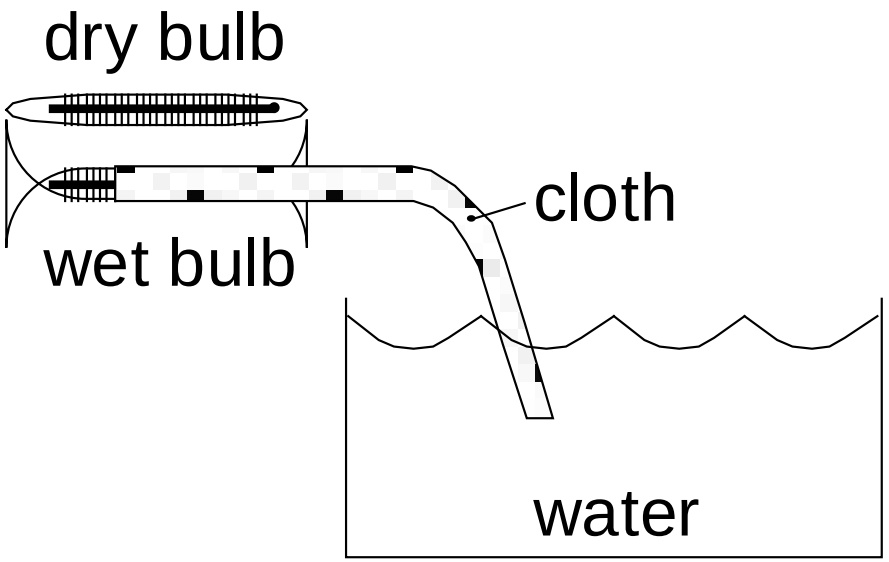
Mechanical

+ Inexpensive
+ No power needed

- 20…90% best range
- Uncertainty from +/-5% up to +/-15%
- Considerable hysteresis
- Responds to changes in humidity very slowly

Psychrometer (wet bulb-dry bulb)

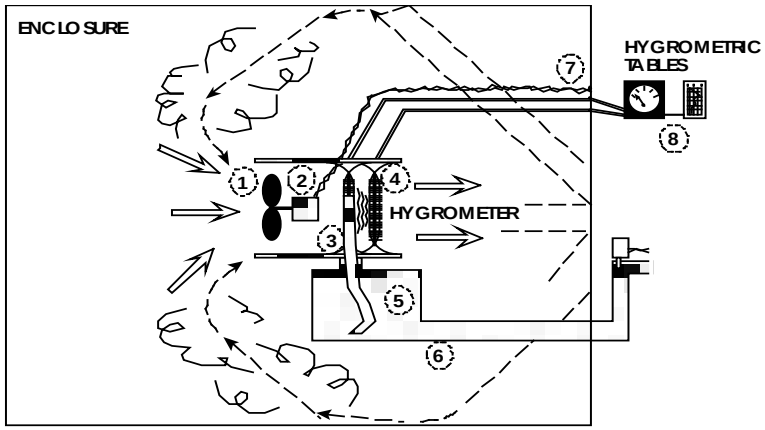
Two matched thermometers over which air is drawn. One thermometer has the bulb covered by a wet ‘cloth’ or ‘wick’. This is the ‘wet-bulb’.



Psychrometer (wet-dry bulb)

+ Simple & fundamental measurement
+ Low price ($35 to $80 for sling)
+ Can have good stability
+ Tolerates condensation without damage

- High uncertainty (+/- 2% to 5%)
- Requires some skill to use & maintain
- Results usually must be calculated
- Requires large air sample
- Sample will be humidified (altered) by water that is evaporating
- Accuracy affected by contaminated/dirty wick/water

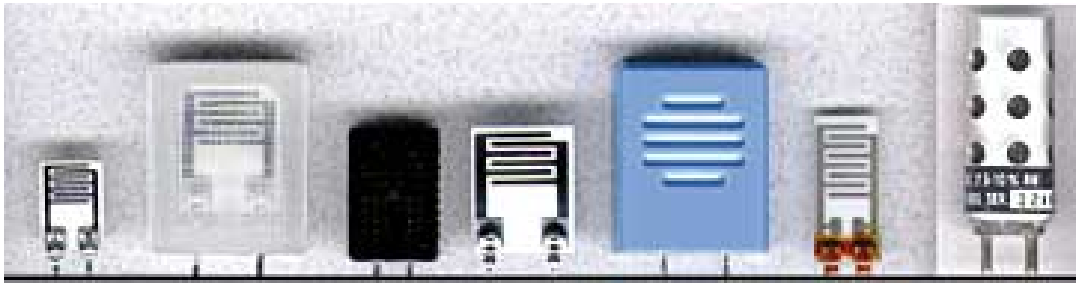


1 fan motor heat introduced
2 turbulance
3 thick wick
contaminated wick
wick quality
porous (ceramic) sleeve
4 non-sealed thermometers
non-identical thermometers
poor resolution instruments
low accuracy instruments
5 poor water quality
water temperature changes affect depression
6 water container material non-plastic
7 two-wire system causes errors
8 tables, accuracy of reading

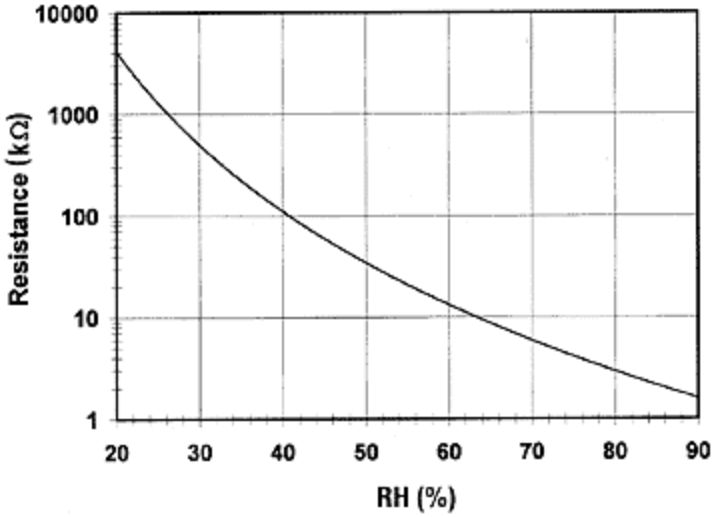
Electrical Sensors

- **Bulk Polymer Resistive**
- **Capacitive – Thin Film Polymer**

Resistive Humidity Sensors



Measures the electrical impedance or resistance of a hygroscopic medium such as conductive polymer, salt, or a treated substrate.



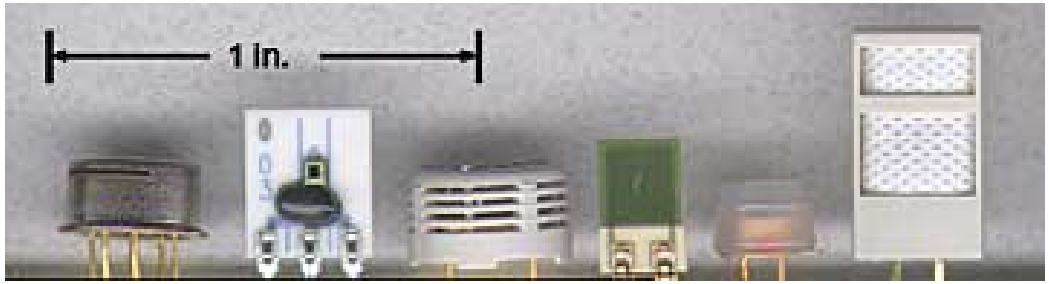
The resistance changes inversely with humidity.

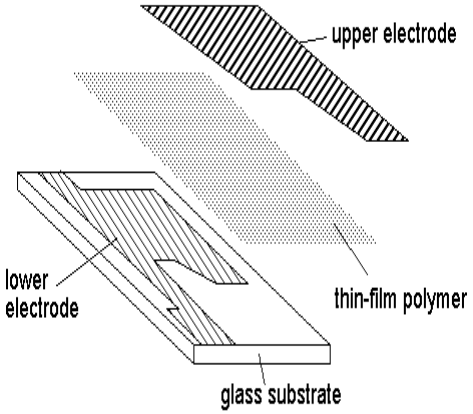
Resistive Humidity Sensors

+ Small and cheap
+ Mass production possible
+ Interchangeable/field replaceable

- Limited range (typically 15...95 %RH)
- High temperature dependency
- Poor stability
- Sensitive to contamination
- Reading altered by all substances that affect resistance; salts, hydrogen, oxidizing agents, other chemicals
- Catastrophic failures in condensing environments

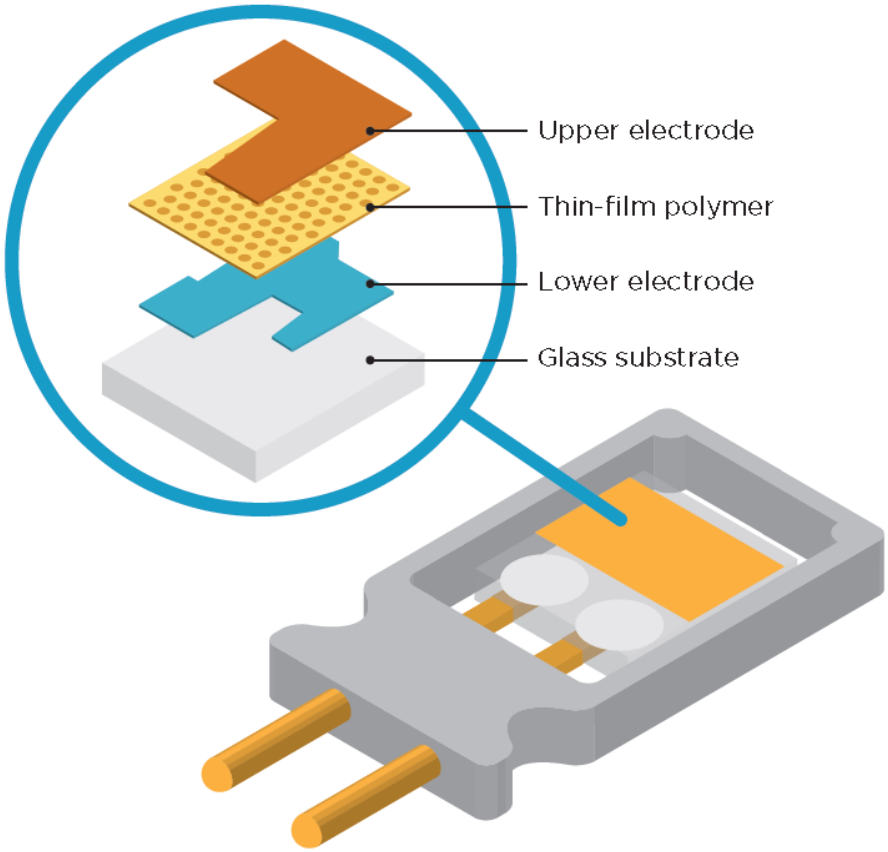
Capacitive – thin film polymer





- Measures the capacitance of an electrode where a polymer acts as the dielectric portion of the capacitor
- The properties of the polymer/dielectric change proportionately with the change in relative humidity which results in a change of the measured capacitance

Structure of the Capacitive HUMICAP® Sensor



Upper electrode

- conductive material
- protects the active material of the sensor from dust, dirt and conductive particles
- lets through water vapor
- functions as one of the two electrodes in a capacitor

Active material

- active polymer film
- absorbs water vapor: amount is a function of ambient relative humidity

Lower electrode

- made of conductive material
- functions as one of the two electrodes in a capacitor

Glass substrate

- base that supports the sensor structure

Where to Use Vaisala HUMICAP® Sensors

- Most relative humidity measurements
- In temperatures of -70 ...+180 °C
- Where humidity can range from 0...100 %RH (with some exceptions in high humidity)
- In processes without any high concentrations of corrosive gases and/or solvents

Capacitive – thin film polymer

+ wide measurement range 0...100 %RH
+ wide temperature range (up to 200C)
+ excellent stability
+ fast response
+ full recovery from condensation
+ Can be resistant to contaminants
+ small
+ low cost
+ require very little maintenance

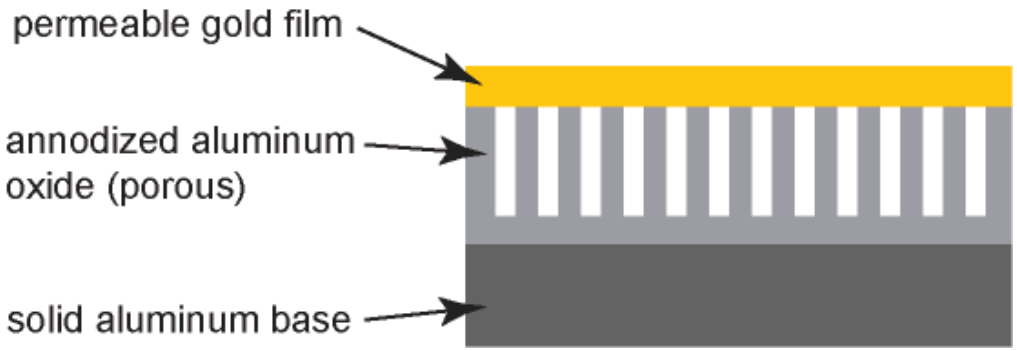
- can be limited by distance from electronics to sensor
- loss of relative accuracy at low end (<5%)
- requires electronics to convert capacitance to relative humidity

Dew/Frost Point Temperature

- **Capacitive – aluminum oxide dewpoint sensor**
- **Chilled mirror hygrometer**

Capacitive - Aluminum Oxide (Al_2O_3)

- Capacitor which consists of aluminum and gold electrodes and an aluminum oxide insulator
- Responds to the partial pressure of water vapor and converted to absolute units (for Td or ppm)



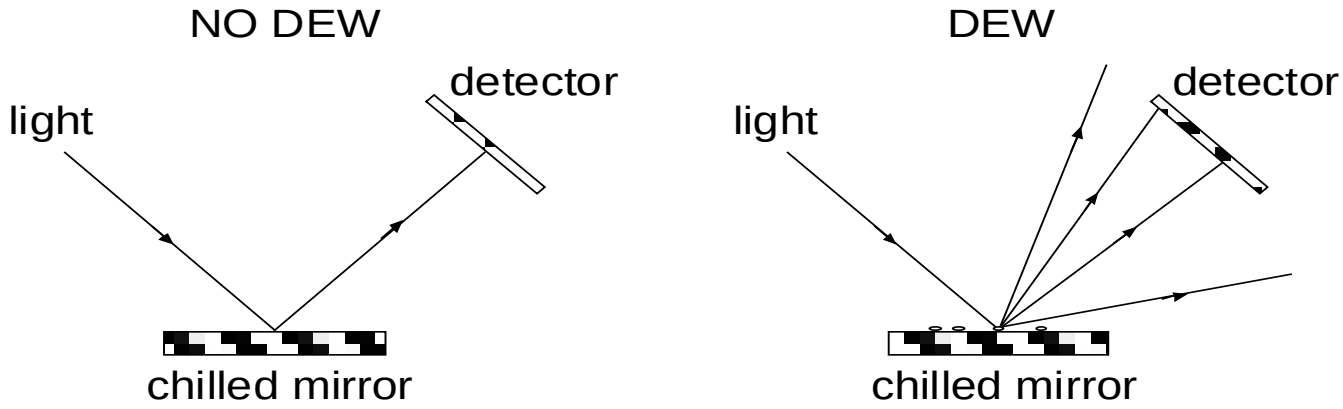
Capacitive - Aluminum Oxide (Al_2O_3)

+ small
+ suitable for in-line site use
+ wide measuring range measures dew point down to -75...-100 °C

- condensation or contamination on sensor causes significant calibration shift
- slow response time
- long stabilization time
- need frequent calibration
- significant drift
- considerable hysteresis

Condensation Hygrometer

Chilled Mirror



Condensation Hygrometer

+ precise measurement (+/-.1C)
+ wide measurement range (-100..+100C)
+ very good long term performance
+ fundamental measurement

- expensive
- usually requires some skill/training to operate
- mirror cannot tell ice or dew
- contamination on mirror causes errors
- requires frequent maintenance
- complex in construction

Other technologies

- Saturated Salt Lithium Chloride
  - This heating/cooling of the bobbin will reach equilibrium. This equilibrium temperature is directly proportional to the dewpoint
- Spectroscopic
  - measures the light at a specific bandwidth where water vapor absorbs the light, based on the principle of infrared absorbance.
- Color change
  - material such as cobalt chloride will change color based on the amount of water vapor in the air as it reacts with the chemical
- Acoustic
  - transmission of sound in air can indicate humidity
- Adiabatic Expansion
  - cooling of air on expansion produces a cloud or fog if the dewpoint temperature is reached

Condensation

- Condensation permanently shifts the readings of:
  - Aluminum Oxides
  - Resistive Sensors
- Thin Film polymers will display 100% until the condensation on the sensor fully evaporates
- Chilled Mirrors are not affected (unless the electronics get wet)

Vaisala Warmed-Probe Sensor Technology

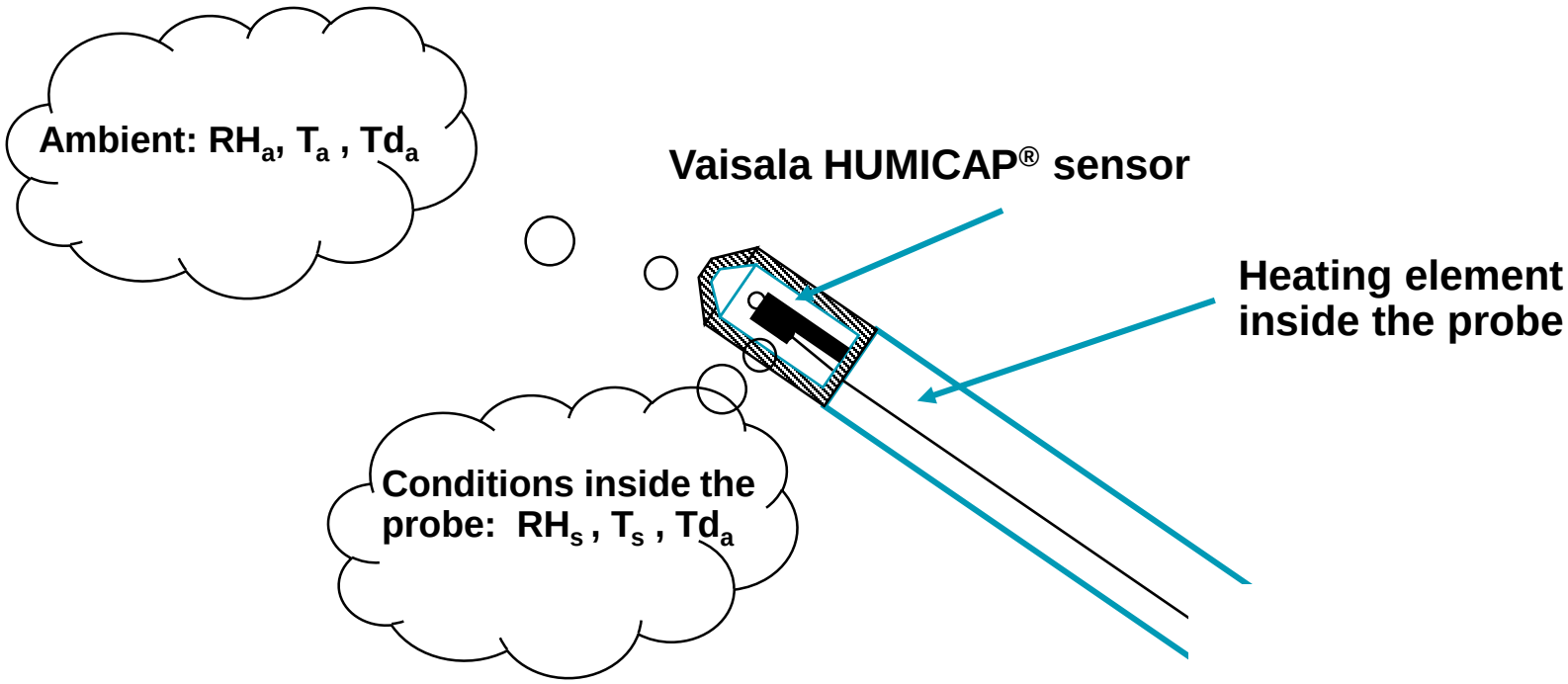
Warmed probe

- Can be selected with or without additional T probe
  - dewpoint output without additional T probe
  - RH & T output with the additional T probe
- Either analog output or digital output (RS485) can be chosen
  - customer does the calibration by using calibration buttons or the serial line

Additional temperature probe

- Has faster T response
- Can be used with or without a warmed probe configuration
- Calibration only through the serial line

Vaisala Warmed-Probe Sensor Technology



Ambient: T_a = 14 °C
RH_a = 97 %RH
Td_a = 13 °C

Humidity sensor: T_s = 16 °C
RH_s = 83 %RH
Td_a = 13 °C (calculated)

NOTE! The heating does not effect in dewpoint!
The ambient temperature is measured with separate T-probe!

Contamination

- RH Sensor are all “air-breathers” and therefore cannot be protected from contamination.
- Cannot hermetically seal the sensor from the environment like is done with temperature sensors

- Particulate vs Vapor Contamination

- Sources of Contaminants
  - Ultrasonic Humidifiers with impure water
  - Volatiles (skin creams, alcohol based products etc)
  - Air

Vaisala Chemical Purge Feature

For applications where the probe will be exposed to chemicals in vapor form a “chemical purge” feature will provide you better long term stability.

- Temp sensor is adhered to the Rh sensor
- Sensing element is rapidly heated to 160-180ºC, results in evaporation of chemical contaminants that have been absorbed by the sensor’s polymer

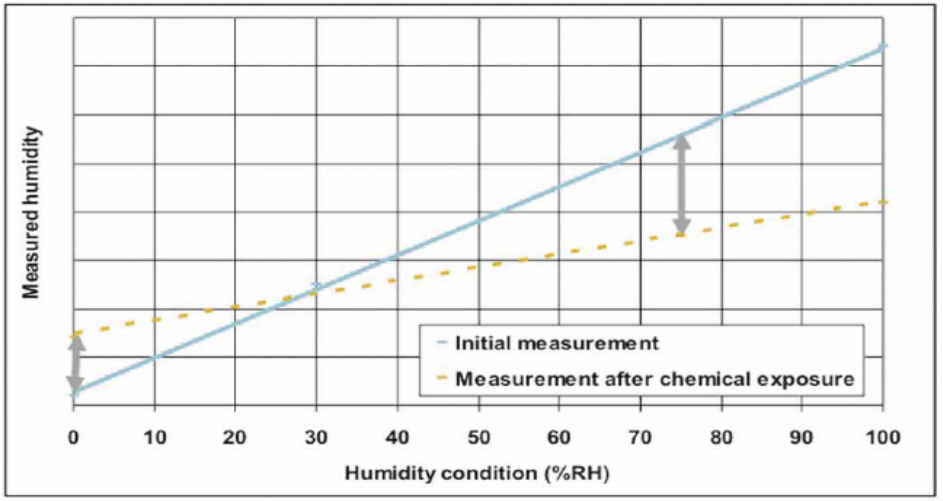


Figure 1. Sensor performance is influenced by absorbed chemicals.

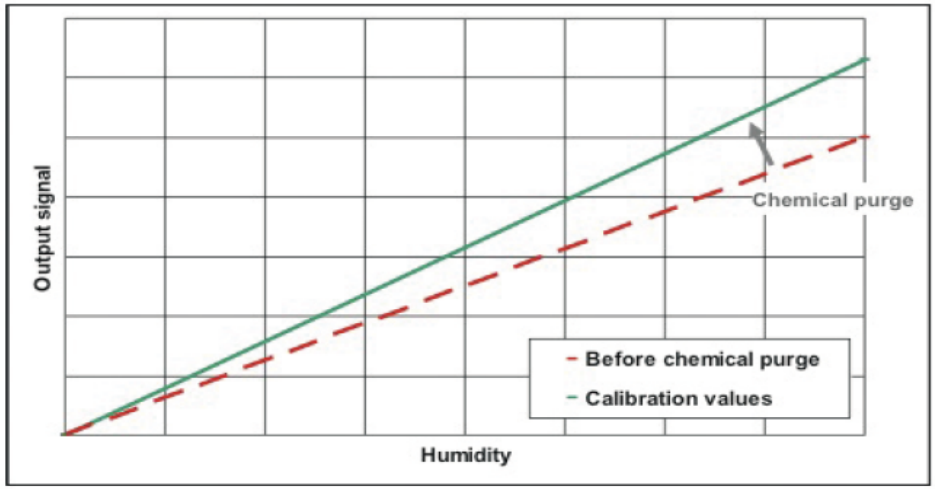


Figure 2. Sensor performance is restored by chemical purge.

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Summary

There are so many options in the market so start that conversation about the sensor technology with your vendors. Good place to start, what type of technology does this sensor use:

- **Mechanical**
- **Electrical**
- **Dewpoint/Frostpoint Based**

Vaisala Humidity Resources

- On-line Humidity Calculator
www.vaisala.com/humiditycalculator

- Humidity Conversion Formulas
http://forms.vaisala.com/forms/humidity_conversion

- Vaisala Humidity Solution
http://www.vaisala.com/en/products/humidity/Pages/default.aspx

For assistance with your humidity measurement

Direct telephone: 800-408-9452

Website: www.vaisala.com

Email: instruments@vaisala.com

Thank you!
This concludes the webinar.

Follow-up email will arrive shortly with the resource links & further contact information.