

Welcome

Vaisala Humidity 101 – Humidity Sensor Technology - Tutorial



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VAISALA

Humidity 101

\ webinar series

Humidity Sensor Technology - Tutorial

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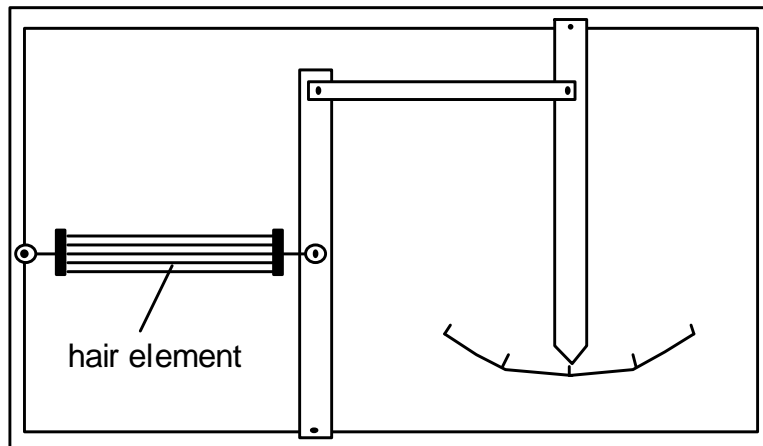
Agenda

1. Sensor Technologies
 - Mechanical/Organic
 - Psychrometers
 - Chilled mirror
 - Electronic
2. Vaisala HUMICAP[®] Training
 - Heated probe
 - Chemical purge
3. Vaisala DRYCAP[®] Training

Mechanical

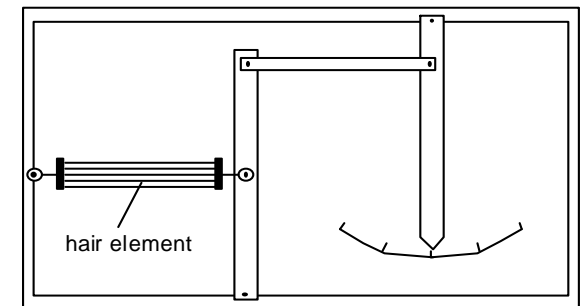
Exploit the expansion and contraction of organic materials with changes in humidity; changes are amplified through the use of levers that move a needle or pointer.

- horse hair, human hair, catgut, goldbeater's skin, textile, or plastic



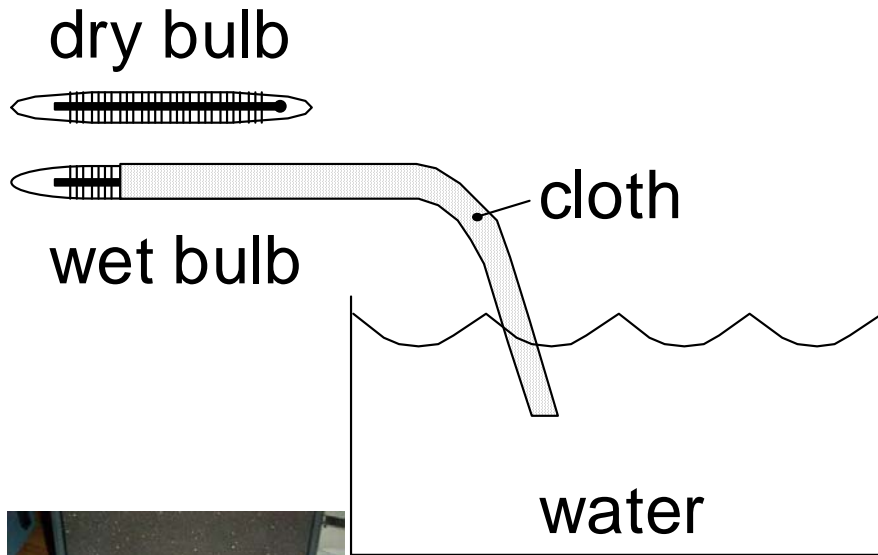
Mechanical

- + cheap to buy
- + no power needed
- 20...90% best range
- Uncertainty from +/-5% up to +/-15%
- calibrated with a wet rag to 100%;
no dry end calibration
- considerable hysteresis
- responds to changes in humidity
very slowly



Psychrometer (wet-dry bulb)

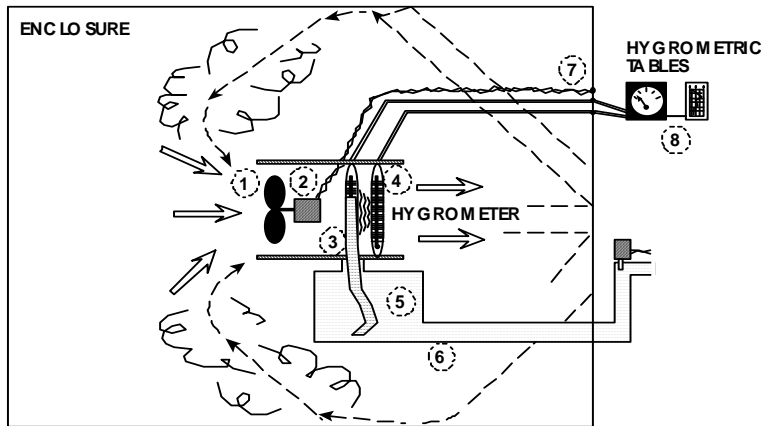
Two matched thermometers over which air is drawn. One thermometer has the bulb covered by a wet 'cloth' or 'wick'. This is the 'wet-bulb'.



Psychrometer (wet-dry bulb)

- + simple & fundamental measurement
- + relatively cheap (\$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



- 1 fan motor heat introduced
- 2 turbulence
- 3 thick wick contaminated wick wick quality porous (ceramic) sleeve non-sealed thermometers non-identical thermometers poor resolution instruments low accuracy instruments

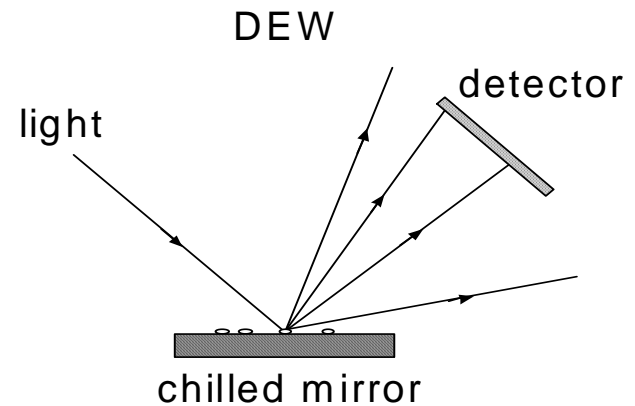
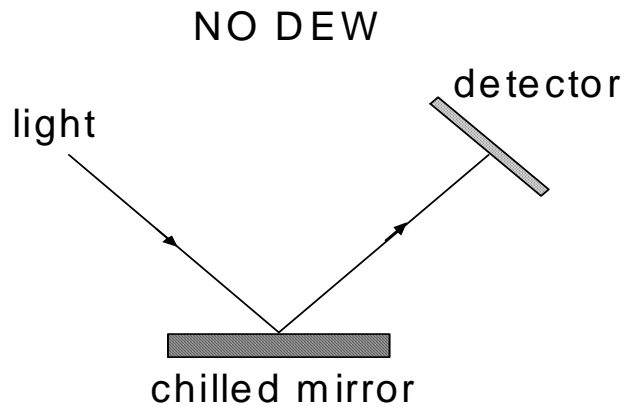
- 5 poor water quality water temperature changes affect depression
- 6 water container material non-plastic
- 7 two-wire system causes errors
- 8 tables, accuracy of reading



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



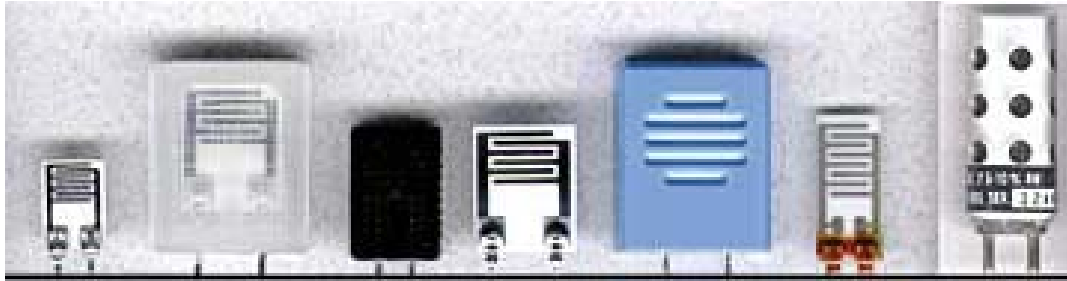
Electrical Sensors

Resistive

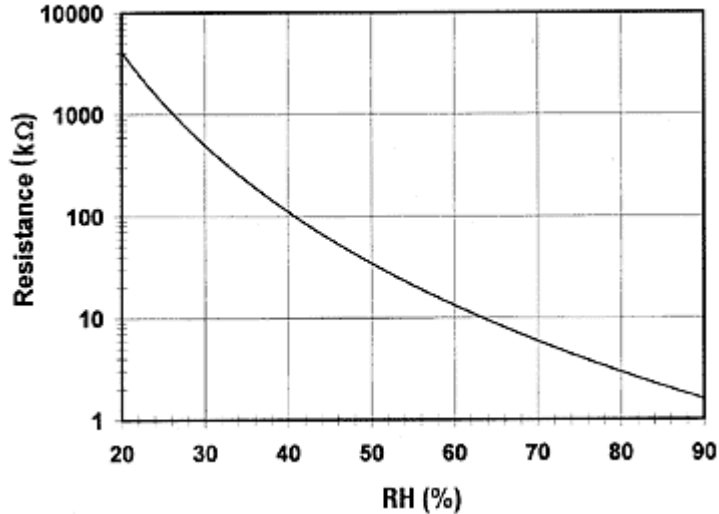
Capacitive – thin film polymer

Capacitive – aluminum oxide

Resistive Humidity Sensors



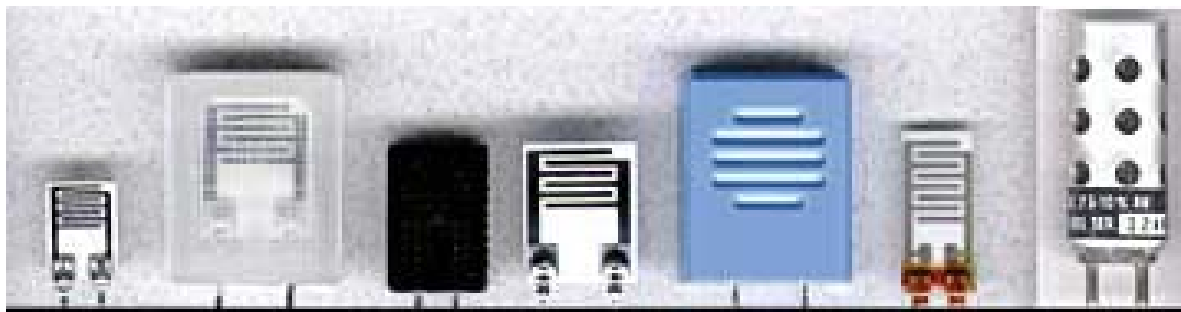
Measures the electrical impedance or resistance of a hygroscopic medium such as conductive polymer, salt, or a treated substrate.



The resistance changes inversely with humidity.

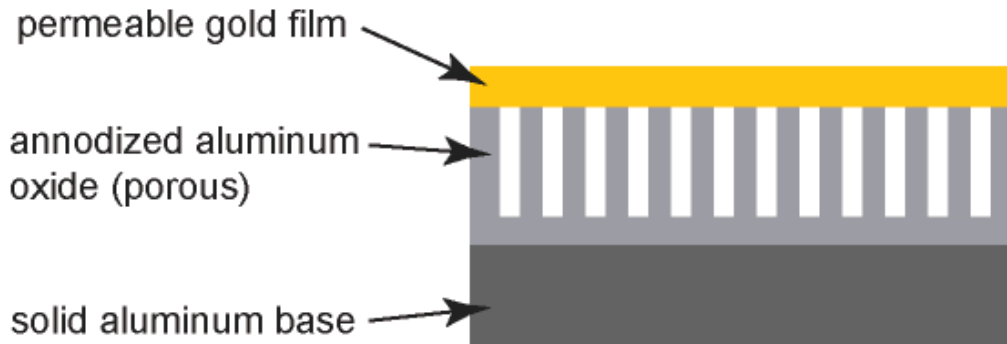
Resistive Humidity Sensors

- + small and cheap
- + mass production possible
- + Interchangeable/field replaceable
- limited range (typically 15...95 %RH)
- high temperature dependency
- poor stability
- sensitive to contamination, condensation
- reading altered by all substances that affect resistance; salts, hydrogen, oxidizing agents, other chemicals



Capacitive - Aluminum Oxide (Al_2O_3)

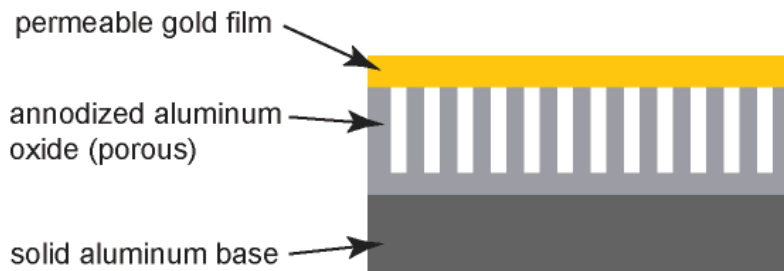
- capacitor which consists of aluminum and gold electrodes and an aluminum oxide insulator
- responds to the partial pressure of water vapor and converted to absolute units (for Td or ppm)



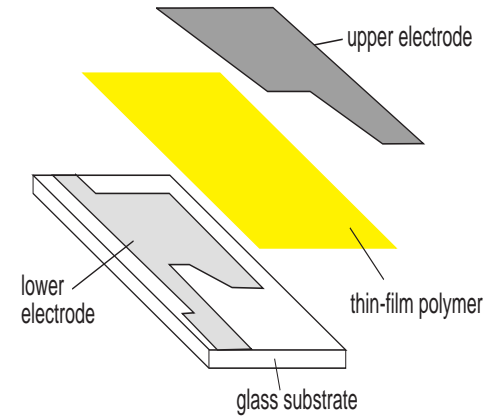
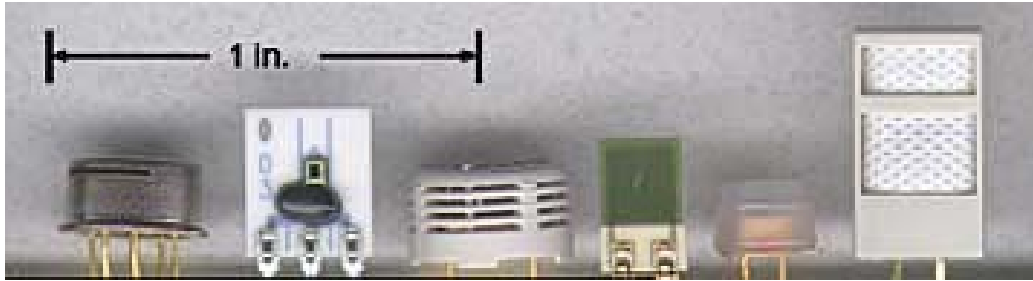
Capacitive - Aluminum Oxide (Al_2O_3)

- + small
- + suitable for in-line site use
- + wide measuring range
measures dewpoint down
to $-75\text{...}-100\text{ }^\circ\text{C}$

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



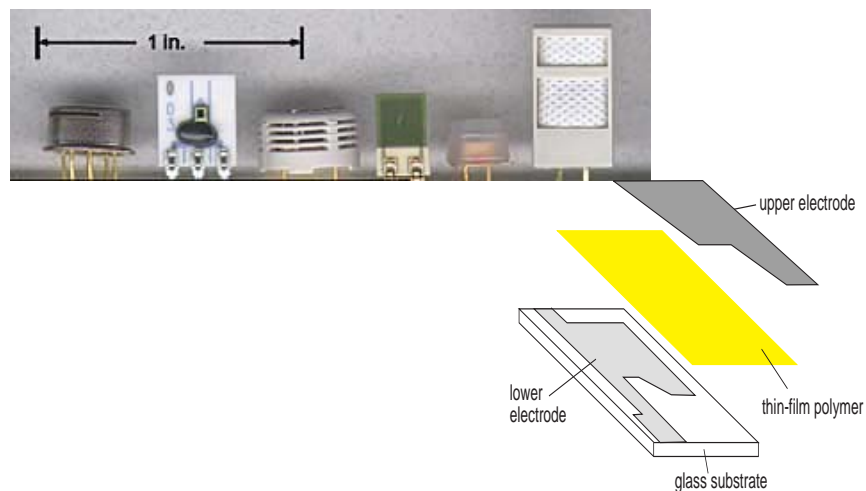
Capacitive – thin film polymer



- 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

Capacitive – thin film polymer

- + wide measurement range 0...100 %RH
 - + wide temperature range (up to 200C)
 - + excellent stability
 - + fast response
 - + full recovery from condensation
 - + highly 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



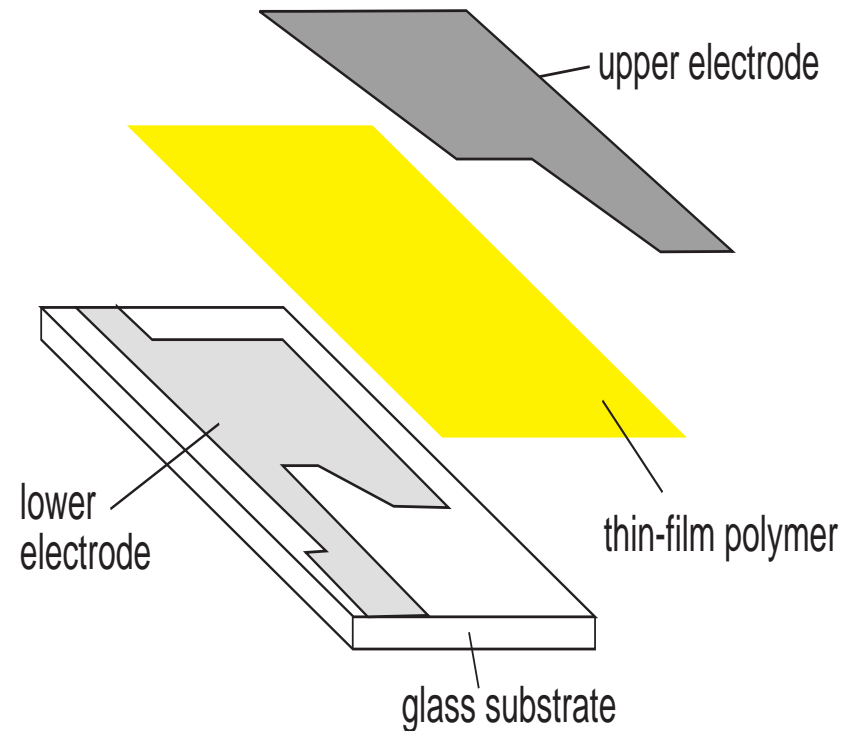
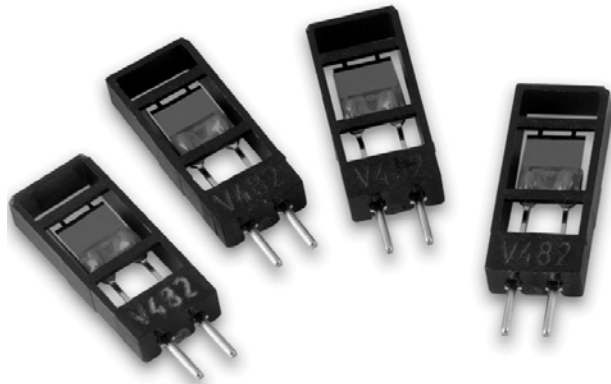
Other technologies

- Saturated Lithium Chloride
 - uses hygroscopic salt as a sensing medium, with voltage applied across the salt and measures current; usually displays 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



For example, the Vaisala HUMICAP®

thin film polymer capacitive sensor



Vaisala HUMICAP® Basic Specifications

- Accuracy - +/- 1% +/-3%
- Relative Humidity Range: 0 ... 100%
- Temperature Range: -94F ... +356F
- Pressure Range: 0...100bar
- Response time(90%): 8s ... 40s

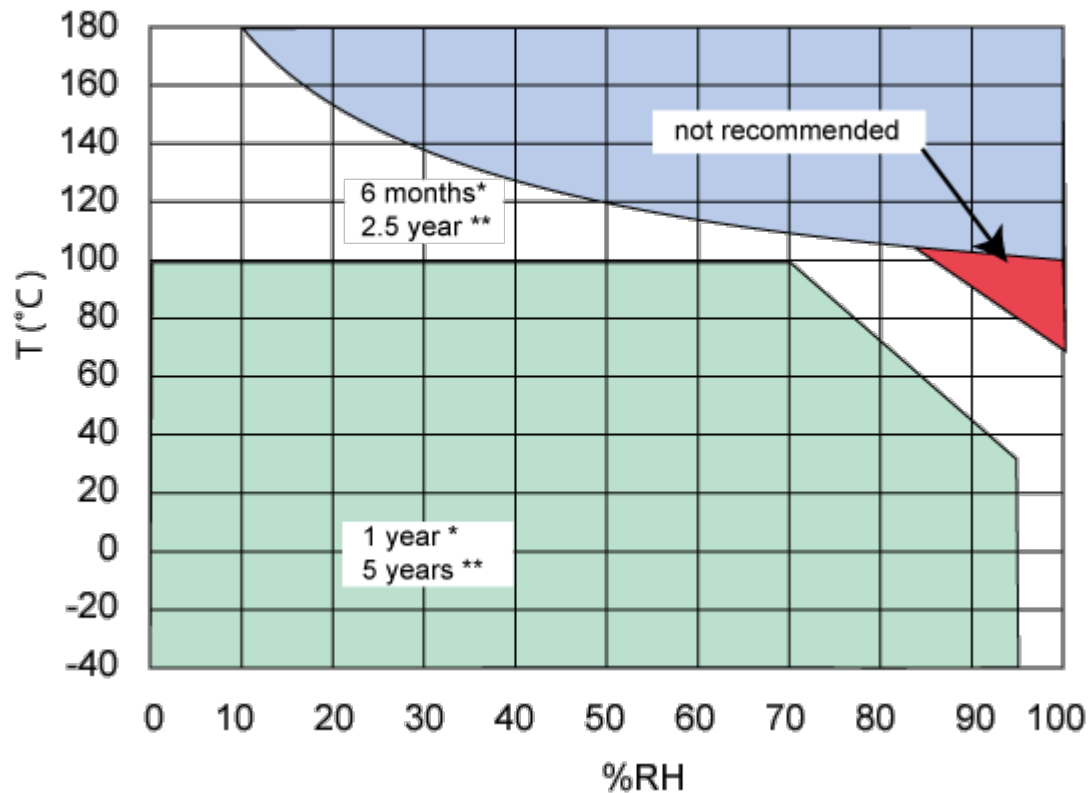
Vaisala HUMICAP® - Maintenance

Calibration Interval

HUMICAP 180R®

* to maintain +/- 1% ... 2%

** to maintain +/- 3.5%



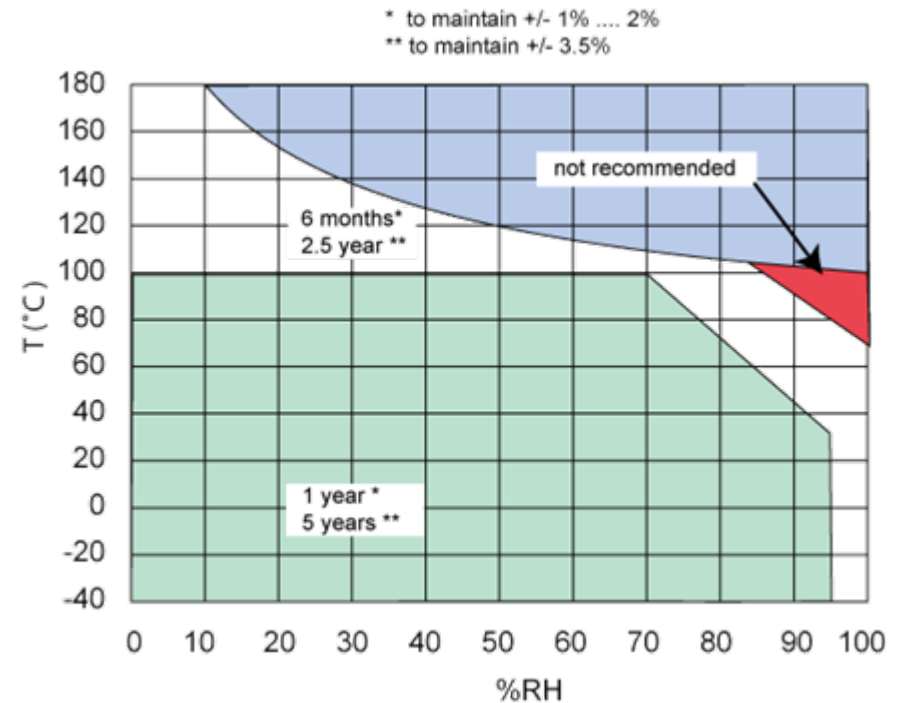
FAQ on use of Vaisala HUMICAP®

1. Is performance affected if water gets on the sensor?
2. Will certain chemicals affect the accuracy?
3. Will dust affect the performance?
4. Can the sensor be cleaned?
5. Can the sensor be replaced?
6. Will it work in gases other than air?
7. What spare parts should I carry?

Vaisala HUMICAP®

Not recommended for use in these conditions:

1. Combined high temperature/high humidity (e.g. +90°C/90 %RH)
2. High concentrations of corrosive gases and/or solvents
3. Temperature > 180C (356F)**
4. Temperature < -70C (-94F)**
5. Conditions beyond instrument specifications



** Note: This is the extreme case, some instruments specifications are more stringent

HUMICAP[®] Heated Probe Technology

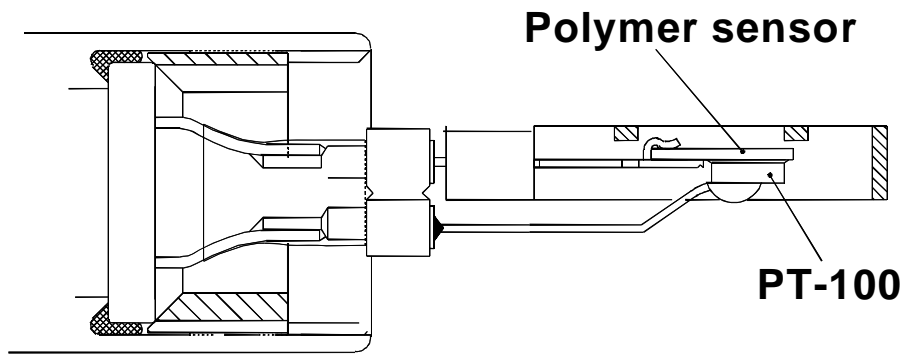
- Entire probe is warmed 2...3 degrees above ambient temperature
- Prevents condensation from occurring on the sensor even in a 100% RH environment
- Also prevents a 'true' RH reading because of the heating
- Output is dewpoint temperature (not affected by temperature)
- Use separate temperature probe for calculating RH if needed



Where is it used?

- concrete curing room
- high humidity testing chambers
- outdoor measurements

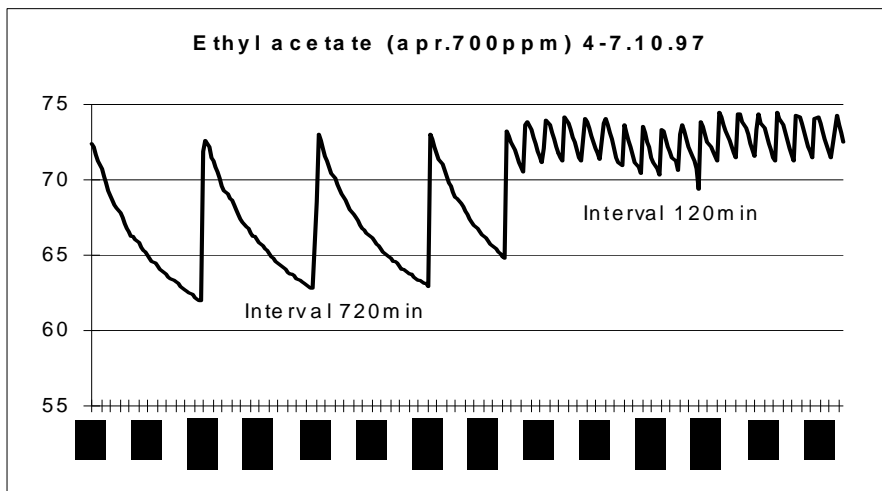
HUMICAP[®]180C – composite sensor



* Available on all HMT330 series instruments

HUMICAP[®]180C - how to use it

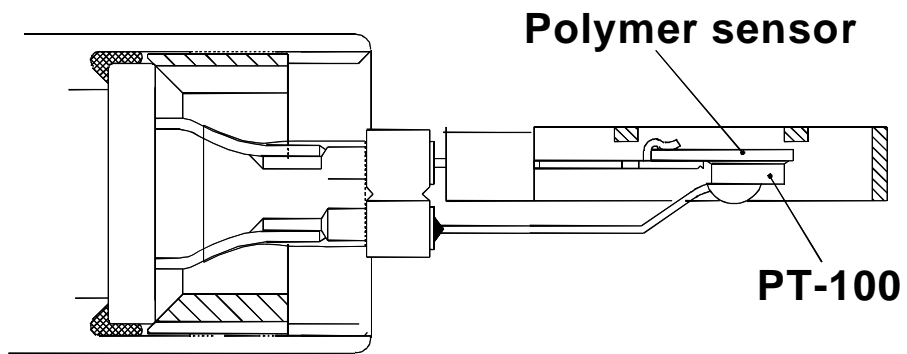
- **Sensor purge (re-gain)**
 - activated automatically once each 12 hours (if turned on)
 - sensor heated up to ~ +180°C
- **XHEAT**
 - Activates at set point; i.e. 95% RH



Where is it used?

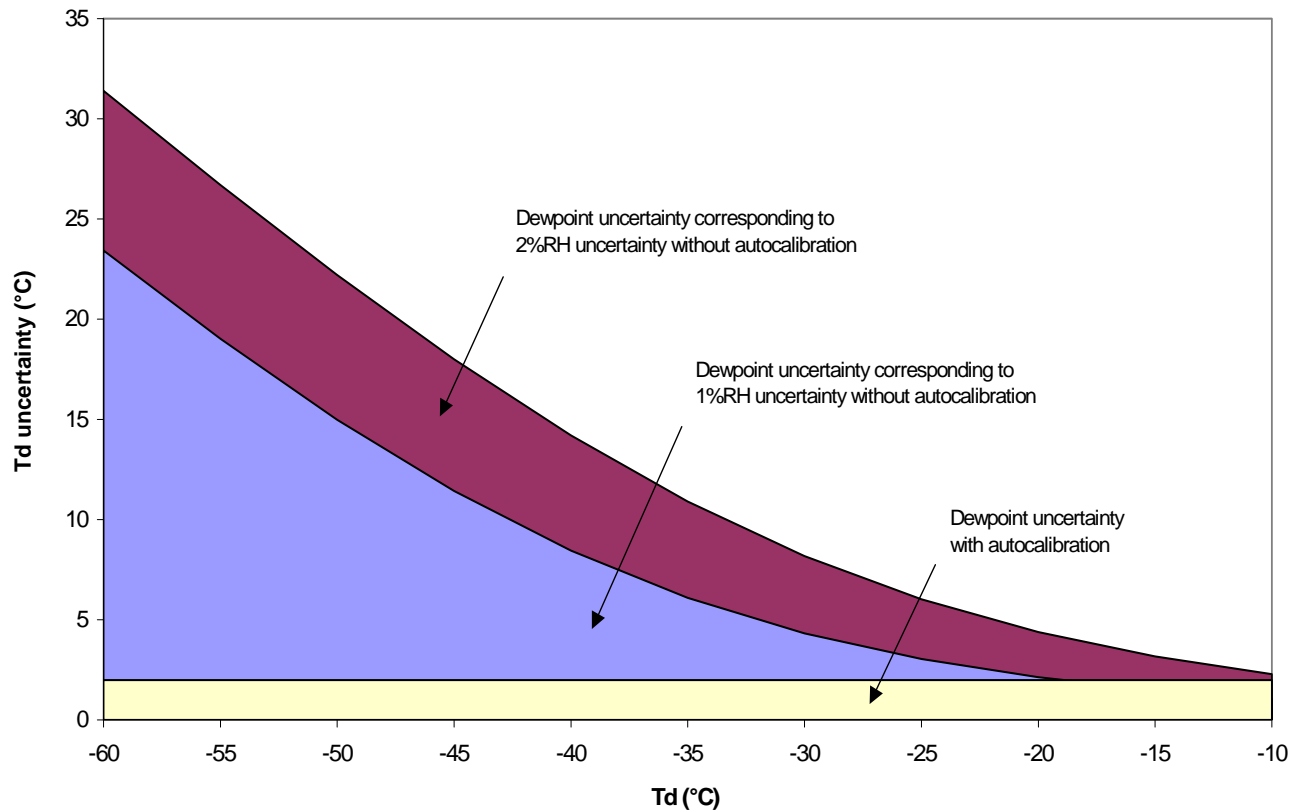
- fuel cells
- certain high conc. chemicals
- Semiconductor mfg

DRYCAP®180



Dewpoint Accuracy with standard polymer technology

Dewpoint Measurement Uncertainty

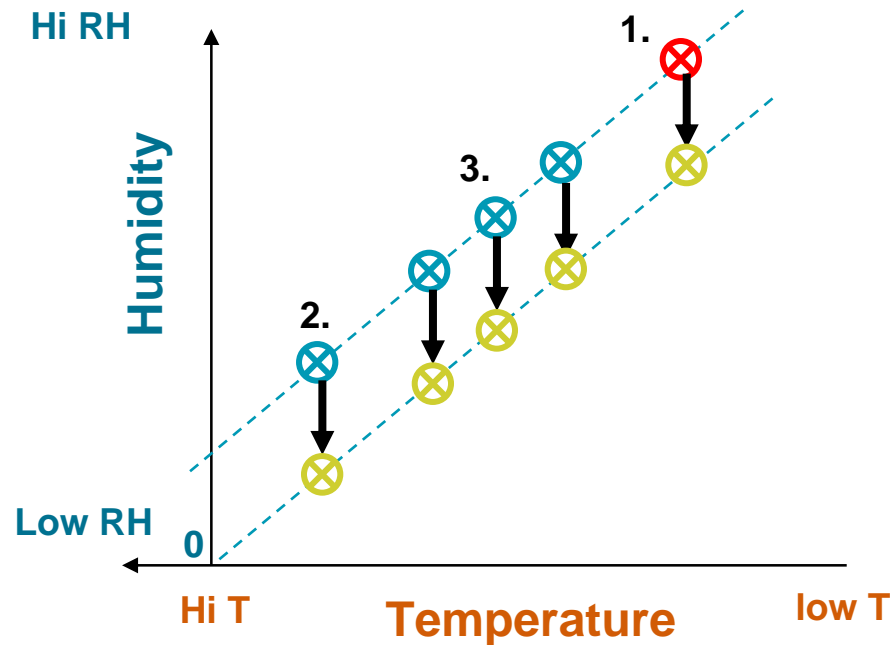
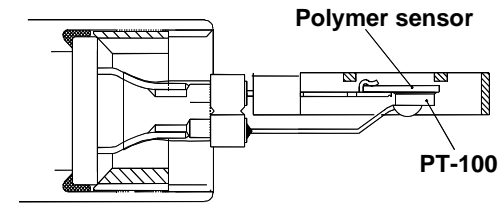


Note: For Td = -76 °F; RH = .08% - how can you get dewpoint accuracy with a polymer capacitor?

AUTOCALIBRATION

+/- 2°C as low as Td = -80°C

- Auto-calibration start:
Sensor warmed ($\Delta T \sim 10^\circ\text{C}$)
RH value decreases when T increases
- Sensor starts to cool down after short warming.
RH reading starts to increase.
- RH and T values logged during cooling phase
- Calculate the offset correction
- Auto-calibration ends: Sensor is cooled and normal measurement mode resumes using the corrected values
- Autocal repeats once each hour and when certain conditions exist



DRYCAP[®] Basic Specifications

- Accuracy +/- 2°C
- Dewpoint range at specified accuracy
 - as low as -80°C [DMT152 only]
 - as low as -60°C [all other DM]
- Temperature Range: -40° ... +80°C
- Pressure Range: 0...50 bar
- Response time(90%): dry to wet 10 sec; wet to dry 10 min

Note: specifications vary somewhat with different instruments, probes, or environments

FAQ on use of DRYCAP®

1. Is performance affected if water gets on the sensor?
2. How often does AUTOCAL run?
3. Can I turn off AUTOCAL?
4. What is the recommended calibration interval?
5. Will it work in gases other than air?
6. Is it safe for explosive environments?

Summary & Questions

1. Sensor Technologies – pros & cons
 - Mechanical
 - Psychrometers
 - Chilled mirror
 - Electrical
2. Vaisala HUMICAP[®]
 - Where & where not to use it
 - Heated probe
 - Chemical purge
3. Vaisala DRYCAP[®]
 - How it works

Summary of Questions from the Audience?

Vaisala Humidity Measurement Resources

- On-line Humidity Calculator www.vaisala.com/humiditycalculator
- Slide Rule Calculator to order – <http://forms.vaisala.com/forms/RequestSlideRule>
- Psychrometric Chart - <http://forms.vaisala.com/forms/RequestPsychChart>
- Humidity Conversion Formulas - http://forms.vaisala.com/forms/humidity_conversion

For expert assistance with your humidity measurement

Email: instruments@vaisala.com

Direct telephone: 800-408-9454

Web: www.vaisala.com/instruments

Next Webinar – Best Practices in Humidity Measurement

Thursday, September 16th , 10:00AM PDT

Full Webinar Schedule info [here](#).

Everyone who registered for Humidity Theory get the invitation for Sensor Technology.

You will receive a follow up email with all of the resource links & link to recording.

Live Humidity Seminars

Philadelphia – August 24th

Raleigh – September 21st

Boston – October 27th & 28th

Los Angeles – December 1st

http://knowledge.vaisala.com/content/Humidity201_Seminars

Thank you!

This concludes the webinar.

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

Link to the recorded version will follow.