Humidity Measurement in Test Chambers and Incubators - Questions and Answers

1. What is the advantage of using a thin film polymer humidity sensor in a test chamber?

The biggest advantages of using capacitive polymer sensors (sometimes called electronic sensors) are low maintenance for the user and the ability of the sensor to operate over a wide temperature range.

Vaisala HUMICAP® polymer sensors can be used in test chambers over the range of -70 to +180 °C (-94 to 356 °F). The measurement is not limited by the freezing or boiling points of water.

Long term stability of Vaisala HUMICAP® polymer sensors is very good, usually requiring only an annual calibration. Expected sensor lifetime is 10 years or more. Unlike other technologies, the sensor does not need a wick, a water supply, a water tank, or associated service related to these components.

2. How is humidity measured above the boiling point of water?

The Vaisala HUMICAP® thin film polymer sensor responds to water vapor, which is of course present at temperatures above and below the boiling point of water. However, there are physical limits to the maximum possible relative humidity value at any temperature above the boiling point. Here is the humidity theory that explains this:

The definition of relative humidity is:

\[ RH = \frac{P_w}{P_{ws}} \times 100\% \]

where \( P_w \) is the water vapor pressure and \( P_{ws} \) is the temperature dependent water vapor saturation pressure.

\( P_{ws} \) is well known from the literature for temperatures up to the critical temperature of 373,98 °C/705,16 °F. The vapor pressure \( P_w \) is independent of temperature, and when \( P_w \) is known there is no problem in defining the Relative Humidity up to the critical temperature.

At temperatures above the boiling point there is a practical limit on the value of relative humidity (%RH) as the water vapor pressure cannot be higher than the total pressure. This means that the maximum relative humidity in unpressurized systems above the boiling point of water is always lower than 100 %RH as shown in the graph.

Frequently asked questions

1. What is the advantage of using a thin film polymer humidity sensor in a test chamber?
2. How is humidity measured above the boiling point of water?
3. How should the humidity sensor be installed inside the test chamber?
4. How is the cable feed through to the chamber sealed?
5. Can sealing materials affect to the humidity sensors?
6. How can sensor accuracy be maintained in test chambers?
7. How does the condensation affect the humidity sensor?
8. What is the difference between 3-wire and 2-wire connection?
For instance, at the temperature of 120 °C (248 °F) the maximum relative humidity is 51%RH. This can be calculated knowing that saturation pressure Pws is approximately 1.987 bar (28.8 psia). In normal atmospheric pressure 1.01325 bar (14.696 psia) the highest possible Pw is also 1.01325 bar. This translates to 51% RH.

Other humidity parameters, such as dewpoint temperature, also have a limit in unpressurized systems. The maximum dewpoint is the same as the boiling point, typically 100 °C (212 °F).

The Vaisala HUMICAP® sensors have been verified for humidity measurement in both unpressurized and pressurized conditions in temperatures up to 180 °C (356 °F). The Vaisala humidity calculator is an easy to use tool for calculation of all humidity parameters in different conditions. www.vaisala.com/humiditycalculator

3. How should the humidity sensor be installed inside the test chamber?

It is recommended that the humidity probe with a short piece of probe cable be mounted inside the chamber (see photo) to make sure that whole probe is in temperature equilibrium with test chamber air. If the probe is installed through a chamber wall and there is a temperature difference between the tip and end of probe it can cause the sensor to be at a temperature different from the actual air. This would mean incorrect RH measurement, or even a condensation risk. For example in a chamber at 40°C/95%RH there will be condensation on the probe if the probe temperature decreases by only 1°C. Such a temperature effect could easily exist due to temperature conduction from the room outside of the chamber.

Consideration should be given for humidity field calibrations when designing the probe installation. If a salt bath calibrator will be used, like Vaisala Humidity Calibrator HMK15, the probe should have a long enough piece of cable inside the chamber to allow for insertion of the probe into the calibrator.

4. How is the cable feed through to the chamber sealed?

Vaisala humidity probes for measurement in test chambers are all fully leak tight. The seal around the probe cable feed through must also be leak tight. Vaisala offers different accessories for this purpose. The use of silicone material is one alternative, but this makes removal and reinstallation difficult and in some cases can cause measurement drift due to chemicals out gassing during material curing.
5. Can sealing materials affect to the humidity sensors?

Some sealing materials that are used for chamber wall or cable feed through sealing can cause humidity drift, increased response time, and hysteresis of the humidity instrument. This can happen when chemicals evaporate while the sealing material is curing. For example, normal household quality silicone sealants outgas acetic acid or methanol during curing and should be avoided. Fortunately this effect is reversible and will fade away once the out gassing of these substances ends. The recovery to original sensor characteristics is faster at higher temperatures.

It is advisable to install the humidity instruments only after these materials are cured. If this is not practical, the yellow protective cap shipped with the Vaisala humidity probes may be used to protect the sensor while sealing materials are curing.

In chambers that are used for very dry conditions it is important to note that some sealing materials absorb humidity and will act as a moisture buffer. Even relatively small amount of these materials can delay drying of the chamber.

6. How can sensor accuracy be maintained in test chambers?

Many different materials are tested and aged in test chambers. Some materials outgas chemicals that may affect humidity sensor accuracy. For conditions where normal HUMICAP® performance is inadequate, Vaisala can provide instruments with a sensor purge function that periodically heats the humidity sensor to remove any chemical contamination. Drift caused by improper sealing materials or other material out gassing is rarely a problem in sensor purge equipped devices.

For instruments not equipped with sensor purge, recovery can be made manually by heating up the chamber to 160 °C for one hour. This is usually enough to remove most typical contaminants from the sensor.

7. How does the condensation affect the humidity sensor?

If water condenses on a humidity sensor the instrument output will typically go to 100% and remain at this level until all liquid water evaporates from the sensor. Long term drift due to repeated condensation events is negligible, but drift may increase when particles or water soluble materials are in the testing environment. It is best to avoid condensation events through careful design and probe installation practices. In the most demanding high performance chambers, a warmed probe can be used to prevent condensation.
8. What is the difference between 3-wire and 2-wire connection?

Both 2-wire and 3-wire installation are used for measurement instruments. A 2-wire installation means that supply power and measurement signal are all connected with just two wires. This is also known as a “loop powered” connection. The current (4..20 mA) in the wires directly indicates the humidity value. A 2-wire connection is simple to install and is resistant to electrical interference.

In a 3-wire installation the supply power is separated from the output signal. This connection type offers a wider variety of signal types, for example, voltage outputs or 0-20mA output. A 3-wired instrument can also offer additional features (for example, sensor purge and probe warming) that are not available with loop powered device due to inherent current limits in the current loop.

2-wire connection (A) and 3-wire connection (B) for the humidity module (1.) from the controller electronics (2.).