measurement matters

Humidity hassles

Control of relative humidity is difficult and rarely managed well. It is generally not well understood by most users and specifications can easily impose contradictory criteria.

Humidity is the amount of moisture in air. The two most common measures of humidity are dew-point and relative humidity. Dew-point is the temperature at which moisture will condense when air is cooled. At this temperature, air is said to be saturated.

Dew-point is most accurately measured using a chilled-mirror hygrometer, by cooling the mirror and noting the temperature at the onset of condensation. The best accuracy achievable with a chilled mirror is about ± 0.04Celsius, although ± 0.2° Celsius is more typical. The more common impedance-based dew-point hygrometers have typical accuracies of ± 2.0° Celsius.

Relative humidity (%rh) at a given temperature is the ratio of the amount of water vapour in the air, to the amount of water vapour that air would contain if it were saturated at the same temperature. As the air temperature is increased, the amount of water vapour remains constant, as does the dew-point. However, the relative humidity falls because air can contain more water at higher temperatures.

Relative humidity is normally measured using impedance-based sensors, which have best accuracies of ± 0.5 %rh, and typical accuracies of ± 2.0 %rh or worse. If accurate relative humidity measurements are required, use a chilled mirror hygrometer and calculate the relative humidity from the dew-point and air temperatures. Conversion equations and humidity calculators are available on the Internet.

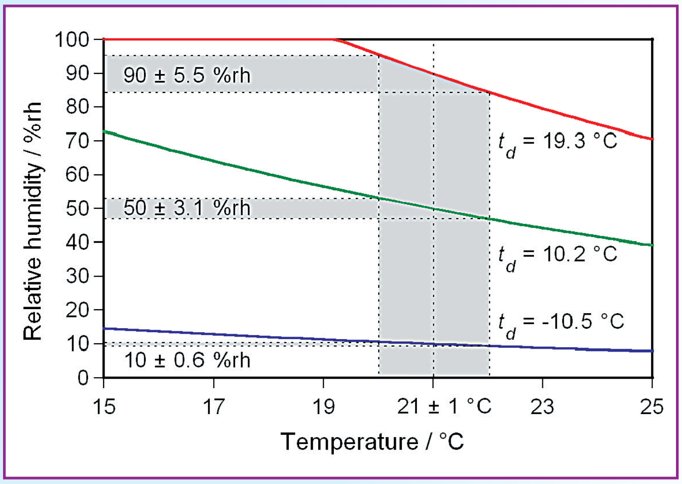
Impedance-based relative humidity sensors are prone to large errors. They are easily contaminated so must be checked or calibrated regularly. Secondly, the sensor response is often temperature dependent, although good quality hygrometers have temperature compensation. It is important to have the hygrometer calibrated over the range of temperature and relative humidity it is to be used.

Finally, they all suffer from hysteresis – a type of memory effect. For a given humidity, the hygrometer will read high if the sensor was previously exposed to higher humidity and vice versa. Good quality sensors have hysteresis less than 0.5% rh. Poor quality sensors may have hysteresis greater than 10% rh.

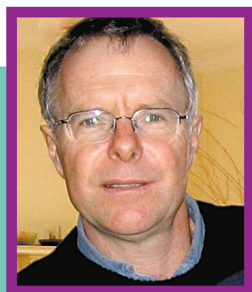
The relationship between relative humidity, dew-point temperature and air temperature is illustrated in the figure. Air at a temperature of 21° Celsius and 50% rh has a dew-point of 10.2° Celsius. The central curve shows that for a constant dew-point of 10.2° Celsius, the relative humidity ranges from 73% rh to 40% rh as the temperature increases from 15 to 25° Celsius. Other curves show constant dew-points of 10.5° Celsius and 19.3° Celsius.

Specifications including both humidity and temperature are often difficult to meet and may be contradictory. Consider a specification: 50 ± 2.0% rh, 21 ± 1.0° Celsius.

If the dew-point remains constant but the temperature varies by one degree Celsius, the relative humidity will vary by 3.1% rh (the shaded region in the figure), which is outside the specification. To comply with the humidity specification, the temperature must be controlled to better than ± 0.66° Celsius. The sensitivity to temperature is greater at higher relative humidity. At 90% rh the sensitivity is 5.5% rh/°C, and the temperature must be controlled to better than ± 0.36° Celsius. These figures assume that the relative humidity sensor is perfect. If the relative humidity sensor is only accurate to 2.0% rh, there is no room for any variation in temperature.



Relative humidity as a function of temperature for lines of constant dew-point (td). ***(see text for details)***



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