HUMIDITY SENSOR IN ACCORDANCE WITH THE ABSORPTION PRINCIPLE

Preliminary view

Humidity is generally recorded as a secondary measurement, i.e. a hygroscopic material is exposed to humidity, and the reaction of the material is measured. Almost all the humidity measurement principles are based on this type of "secondary measurement", through the wet and dry thermometer in the psychrometer, with the dew-point level by means of the dew formation on a cooled reflective surface, with the LiCl sensor by means of an equilibrium flow over a saline solution, with the capacitive sensor via the change in a polymer's dielectric.
It is easy to imagine that all these humidity measurement principles have different advantages and disadvantages. The key features of the filaments in the GALLTEC sensors are their stability, insensitivity to dust and dirt, long-term stability and the fact that the sensing element can be cleaned in normal water.
The polymers in capacitive sensors are similar in structure to the polymer of the GALLTEC filament. Whilst the extremely thin polymer layer (approx. 1 µm) and the thin covering electrode of the capacitive sensor enable facilitate a quick reaction to changes in humidity, this advantage is counteracted by a disadvantageous sensitivity to dirt and dust. If this thin layer has unprotected exposure to the flow of air from an air-conditioning system, for example, the polymer layer quickly sustains damage. If this sensor is protected by a filter, this increases the service life, however there is a danger that the filter will become so clogged with dirt and dust that changes in moisture are no longer detected by the actual element.
Recap: If you need a robust solution or if the measuring range of 30...100% RH is sufficient at a reaction time arising from a half-life of 1.2 min or if the level of humidity being measured is almost 100% RH, the GALLTEC filament (FG or HG series) is the best solution.
However, if you require a quick measurement and have to measure humidity below 30% RH, use the GALLTEC capacitive sensor (FK series).

The author wishes to demonstrate a humidity sensor with **polymer plastic fibre** which can be used in many areas of humidity measurement and control technology on account of its low price.

Description of the sensor :

The Polyga® humidity measuring element consists of several synthetic fabric bands each with 90 individual fibres with a diameter of 3 mµ each. In their untreated state, the synthetic fibres are not hygroscopic - their hygroscopic properties are acquired by means of a special process which allows the synthetic fibres to absorb moisture. The molecular structure of the individual fibres is arranged lengthways. When water is absorbed, the molecular chains alter, the outward result being a change in length. A loss of water has a converse effect on the fibre. If the fibre is in equilibrium with the air humidity, there is neither absorption nor a loss of water. The length at this point serves as a gauge for the relative humidity.
If the measuring element is exposed to an air humidity of 100%rh, a film of water forms on the surface of the element (dew point). The physical effect is one as if the measuring element had been immersed in water. The measuring element is saturated. An ideal fixed point is thus attained for adjusting or controlling the sensors. The measuring element is waterresistant. Once administered to the Galltec measuring element, the hygroscopic properties remain stable, the sensitivity remaining until it becomes destroyed by extraneous influences. Regeneration as with hair measuring elements is not necessary, but does not cause any harm.

Influence of dirt

Like with almost all humidity sensors, deposits are damaging. These deposits eventually form a water-impermeable film on the surface of the sensors. Consequently, such sensors cannot be used for wood drying, for example, because resin aerosols contained in the surrounding air are deposited on the measuring element, depending on the type of wood to be dried. The same is also true for paint drying installations which contain paint aerosols in the surrounding air.
The water resistance of the Galltec humidity sensor permits cleaning in water. This is an important advantage when the sensors are used in extreme atmospheres.

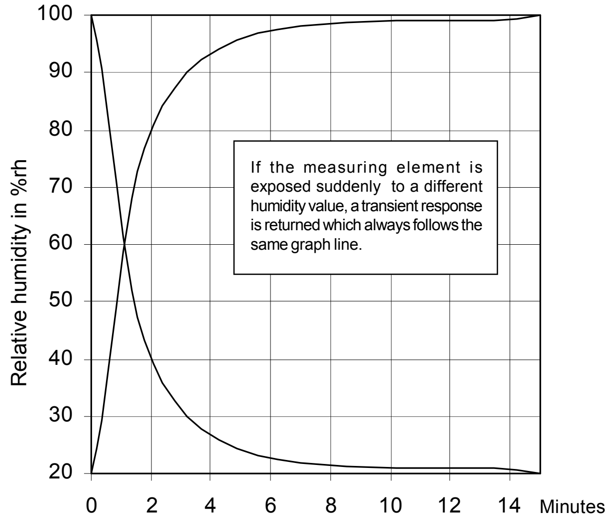
Ageing

In order to maintain their long-term stability, it is important that the measuring elements undergo a special ageing process, details of which cannot be given here.

Reaction of the sensor

Due to the law of diffusion, there is a time delay before the fibres are saturated during water absorption. This is a decisive factor when determining the reaction time. Thus, for one individual fibre with a diameter of 3 mµ, a short saturation time (several seconds) can be measured. Empirical investigations show that bundled or woven fibres, as are used here in the Galltec sensor, give rise to a longer period prior to saturation. This is because the individual fibres impede each other during water absorption and/or water loss, and the ensuing humidity does not register until later. Measurements have shown that, at a wind speed of 2 m/sec. the half-life period is 1.2 mins. This represents an effective period of approx. 30 - 40 mins.

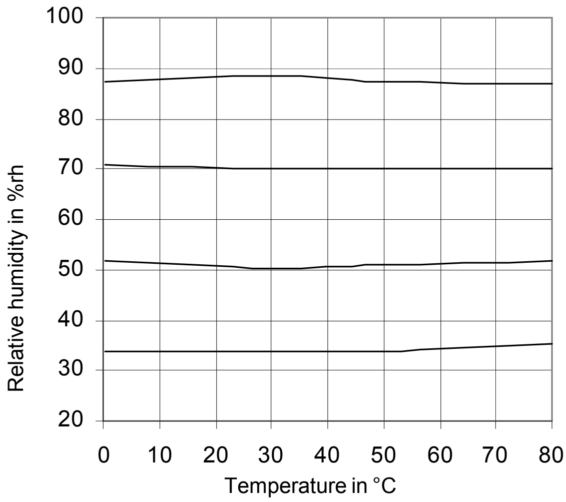
Half-life period



Transient response of the measuring element between 20 and 100%rh.

Thermal behaviour

The average deviation of the thermal behaviour is about 4%rh. The sensors are set at a room temperature of 23°C.



80º C is given as the maximum temperature value. Higher temperatures can only be tolerated for a short period of time. The eventual result is a change in the molecular structure which causes a constant error. The maximum temperature of 80º C only applies, however, if no harmful substances (acids, solvents etc.) are present in the medium.

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Behaviour at temperatures below 0°C

It is not expected to sustain any damaging effects at temperatures below zero. However, there is no change in length here which can be used for a measuring signal. Looking at the hx diagram for moist air, it is apparent that the moisture curves run together at temperatures below zero. Relative to the absolute water content of the air, this yields an extremely small quantity of water for the 0%rh und 100%rh range which still has to be divided into 100 parts (0...100%rh). At an air temperature of -20°C, there is 0.8 g of water per kg of dry air and at 100%rh, i.e. in saturated air. If this 0.8 g of water is now divided into 100 parts, this leaves 0.008 g of water relative to 1%rh. This quantity of water is too small to make the sensing element respond and to bring about an effective change in length. However, the measuring element can be exposed to temperatures of -40°C without damage.

Characteristics of the sensor

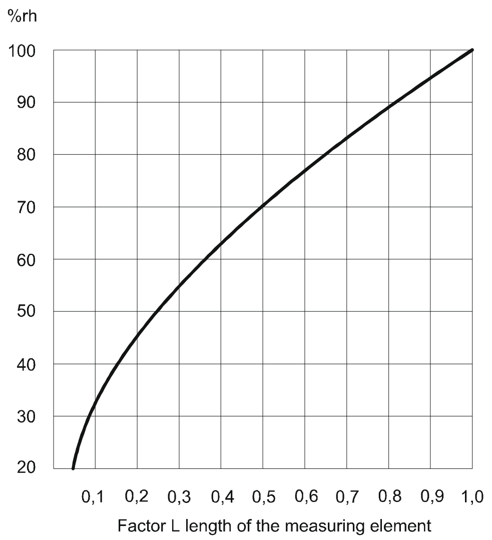
The absorption behaviour of the Galltec sensing element, relative to the humidity in the air, is not linear, i.e. the changes in the length of the element are dependent on the relative humidity range. When the relative humidity is high, the sensing element responds with a large change in length, and vice versa when the relative humidity is low. The characteristic curve is similar to a parabola segment.

The formula for this characteristic curve is as follows:

$$\Delta L = E \cdot 3{,}7 \cdot 10^{-3} \left(A \cdot [\varphi + D]^{2} - C\right)$$

whereby:

ΔL = Change in length in mm relative to l_0 = 100 mm
E = Sensitivity of the sensing element in mm, relative to l_0 = 100 mm between 0 and 100%rh
A = 0,02583
C = 0,1317
D = 2,2581
φ = humidity in the air in %rh



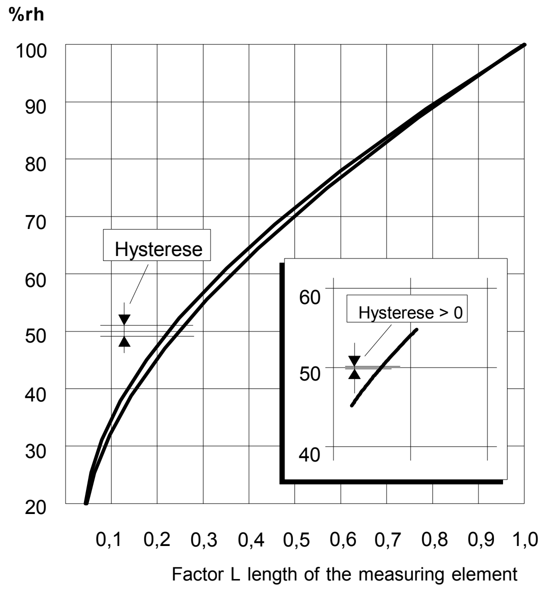
Characteristic curve of the Galltec sensing element for measuring the change in length depending on the relative humidity.

Measuring precision of the sensors

A degree of measurement uncertainty, which decreases as the humidity rises, is calculated depending on absorption principle for the sensing element and its influencing factors, described above. This is already evident from the fact that the sensors are adjusted with the fixed point 100%rh (water) and from the fact that the temperature coefficient is small at high levels of relative humidity. This yields a degree of measuring accuracy of ±2.5%rh in the 40...100%rh range and ±3.5%rh in the 20...40%rh range. These sensors should not be used for recording measurements at RH levels below 20%.

Hysteresis behaviour of sensors

There is a physical backlash between the absorption and discharge of the water by the sensing element which occurs as a hysteresis. The curve below demonstrates the hysteresis when relative humidity changes from 0..100%rh and from 100..0%rh.



The greater the backlash is, the greater the hysteresis also is. However, as humidity ranges of this magnitude rarely occur in practice, the hysteresis in the case of small fluctuations in humidity tend to be somewhere above 0. Sensors which are used with controllers display an extremely small hysteresis. In the case of PID-action control for example, the moisture being controlled remains virtually constant.

Calibration

Equipment with Galltec sensors is correctly set by the factory at a room temperature of 23°C and 50%rh.

If, however, a further adjustment is necessary, the following procedure should be adhered to :

* Ensure that the ambient humidity as well as the ambient temperature are constant.
* If possible, use a psychrometer for testing.
* Leave the equipment to be tested for *a minimum of 1 hour under **constant test conditions***.
* All Galltec sensors are equipped with an adjustment facility. In most cases this involves an adjuster screw fixed with screw securing lacquer. When the lacquer is removed the screw can be adjusted. After calibration, the adjuster screw should again be secured.

Influence of relative humidity

at a temperature fluctuation of ±1°C, relative to different room temperatures.

	10°C	20°C	30°C	50°C
10%rh	±0.7%rh	±0.6%rh	±0.6%rh	±0.5%rh
50%rh	±3.5%rh	±3.2%rh	±3.0%rh	±2.6%rh
90%rh	±6.3%rh	±5.7%rh	±5.4%rh	±4.6%rh

Consequently, it is extremely important that the temperature remains constant during relative humidity measurements. The air must be homogeneous, i.e. the humidity and a temperature must remain constant for the entire duration of the measurement.

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