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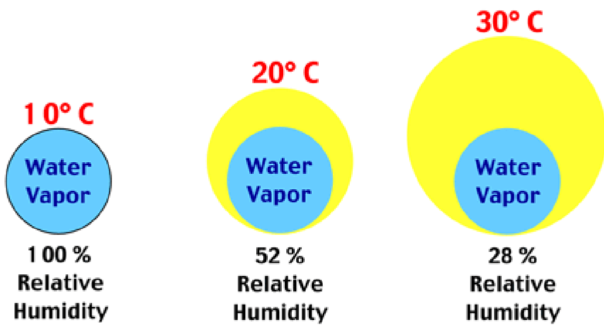
Principles of Moisture Measurement

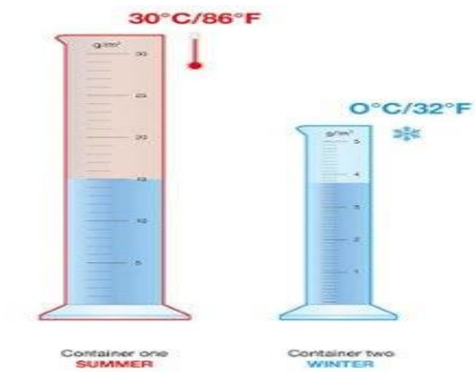
By: Douglas Wright, President

There are many methods of reporting and analysing moisture. Here below are listed some of the more common methods for rapid analysis and explanations of them.



Relative Air Humidity

Relative humidity shows the degree the air is saturated with water vapour. The key principle of Relative Humidity or R.H. is that it measures the moisture content of air relative to the temperature.



Absolute Humidity

Absolute humidity shows the amount of water contained in the air, regardless of temperature. It is expressed in grams per cubic meter of air (g/m3).

Moisture content

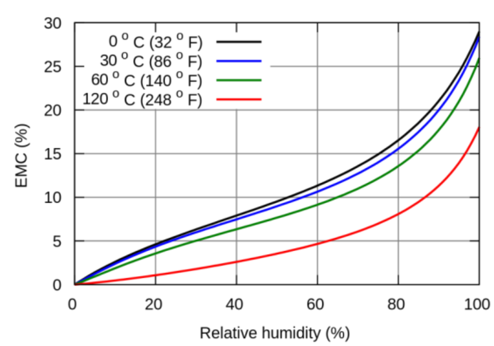
Water content or moisture content is the quantity of water contained in solid materials like crops or wood, paper and other materials, in relationship to the total weight (or dry weight).

300g corn	300g hand corn	300g rye	300g triticale
5..40%	5..40%	5..28%	5..28%
			

Equilibrium Moisture Content EMC

Hygroscopic materials: wood, paper, grain

The **equilibrium moisture content** of a hygroscopic material surrounded at least partially by air is the moisture content at which the material is neither gaining nor losing moisture. The value of the EMC depends on the material and the relative humidity and temperature of the air with which it is in contact.



Dew point

The dew point is the temperature at which the air is saturated with water vapour. Above the dew point, liquid water will begin to condense on solid surfaces.

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Conductance Measurement

Electrical conductivity or **specific conductance** is the reciprocal of electrical resistivity, and measures a materials ability to conduct an **electric current.**

This measuring principle is based on the fact that electrical conductivity changes according to the moisture content of a porous material. Electrical conductivity in dry material is lower than in wet material. For a measurement of electrical conductivity two electrodes are pressed against, plugged or driven into the material. This way the resistance between these two electrodes can then be measured by highly specialized and sensitive electronics. An optimised measuring procedure (that doesn´t feature the disadvantages of a standard resistance measurement) ensures right measuring results also for long term measurements.

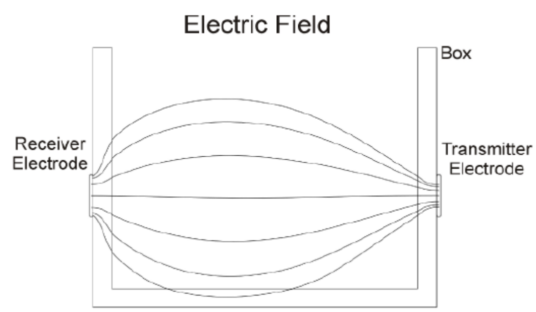
The evaluation electronics converts the measured conductance value into weight percent and shows the water content on the display.

Devices using conductance measurement:

[FLH](), [GF series](), [PM5](), [FLM](), [RM1](), [SLW](), [Marathon Dataloggers](), [Scigiene Wireless Systems]()

Devices using conductance measurement:
BL2, BLL, WLW, BLW, wood chips moisture transmitter,

Capacitive Dielectric Measurement



The capacitive measuring principle utilises the different dielectric coefficient (electric field permeability of a material) of dry, nonconductive material (approx. 2-10) and water (approx. 80). The wetter the material, the higher is its dielectric coefficient. A capacitor makes this coefficient measurable.

This capacitor consists of two electrodes integrated in the sensor, building an electric high-frequency field (dielectric) in the material to measure.

Materials with higher water content in the stray field of the capacitor are reflected as a higher capacity.

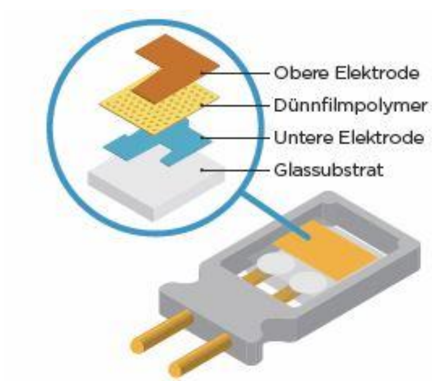
The evaluation electronics convert this capacity value into weight percent and shows the water content on the display.

Devices using dielectric principle:
BMA, BM1, BM2, BP1, M20, BLO with universal sensor

Devices using dielectric principle:

[FSA](), [FSG](), [FS1](), [FS2](), [FS3](), [FS4](), [GE1](), [SW1](), [PMP](), [RP6](), [MS4](), [LM5](), [LM6]()

Capacitive Humidity Sensors



A capacitive humidity sensor is used to measure relative humidity with a usual range of 5 to 95 % relative humidity. The sensor is a capacitor, made from two metal electrodes with a porous dielectric substance between them. Water vapour is able to penetrate this layer, changing the total capacitance. These are commonly used on hand held probes, dataloggers and other portable devices as well as for Water Activity meters.

Since the membranes require the absorption or loss of moisture to affect the change in capacitance these can also become slower or change readings if they become dirty (dust or other particles) or damaged (solvents or corrosive gases), so frequent testing and recalibration to ensure ongoing stability and accuracy is important.

Fast measurement due to small size and thin polymer film

Resistant to most chemicals

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Dirt on the sensor doesn´t influence the accuracy, but increases the reaction time.
Devices using capacitive humidity sensors are:
AW1, AW2, AW3, RH2, RH5, RH6, RH1, Marathon Dataloggers, Scigiene Wireless Systems

Water activity

Water activity or a_w is the relationship between the partial water vapour pressure in food (p) and the saturation vapour pressure of pure water (p0). It is an important indicator for product quality in the food, tobacco and pharmaceutical industry and is indicated in an a_w value from 0…1
These can be done using a variety of sensor types but are typically Capacitive Humidity Sensor or Chilled mirrors.
See our``Water Activity Real vs Theoretical'' article for more detail on this.

Chilled Mirror

Moisture will condense on a surface as the water vapor reaches saturation. Using this principle chilled mirror dew point hygrometers are able to measure the moisture. They use a chilled mirror and optoelectronic mechanisms to detect condensation on the mirror's surface. The temperature of the mirror is controlled by electronic feedback to maintain a dynamic equilibrium between evaporation and condensation, thus closely measuring the dew point temperature. An accuracy of 0.2 °C is attainable with these devices, which correlates at typical office environments to a relative humidity accuracy of about ±1.2%. These devices need frequent cleaning, a skilled operator and periodic calibration to attain these levels of accuracy. Even so, they are prone to heavy drifting in environments where vapors or otherwise impure air may be present. While theoretically very accurate this only works when the instrument is cleaned regularly and there are no vapors' to contaminate the mirrors, and temperatures are controlled precisely. All of these factors lead to a low degree of repeatability and real accuracies far below those of good capacitance sensors so we do not offer this technology.

Wet Bulb Hygrometer

The principle of here is that a wick is immersed in water and covers one temperature probe. A second probe is un-wicked and the differential between the 2 is used to correlate the moisture. The reason this works is that the wick loses moisture to the air resulting of heat loss in the wicked probe. The rate of cooling is relative to the temperature and the R.H. of the air surrounding the sensor. These are large and somewhat cumbersome and require frequent wick replacement. But for high temperature applications with corrosive gases or other airborne fumes that might coat other sensor types this is in reality the most suitable option.
Contact Scigiene for details

Oven drying and Moisture Balances

Both methods use the principles of difference by weight to determine the actual moisture.
Oven drying is the Granddaddy of all moisture analysis methods. And when testing new products it is still the failsafe method of analysis. However it is slow and requires a high degree of labour and technical skill. Temperatures that are too high can carbonize samples and loose mass not related to moisture or create a hard shell that actually traps moisture or drive off other volatiles leading to false results.
To compensate for the labour and slow speed of oven drying the moisture balance was developed. These also dry the sample and take weights before and after drying and automatically calculate moisture. The problems of oven drying are however amplified if not used correctly. Up to 50% of moisture balances in use are not used correctly due to operators trying to push for faster results. Even then they are still slow compared to other methods and only one sample at a time can be processed.
See:
https://www.scigiene.com/HM-12176