THEORY

Contents

Fundamental terms of humidity measurement

Water vapor density (absolute humidity)

This is the amount of water vapor (kg) contained per unit volume (m^3) of the gas mixture. In a gas mixture the water vapor generates a certain partial pressure that is part of the total barometric gas pressure. The vapor pressure can only rise to its saturation limit, which is determined by the temperature. Thereafter water is given off in liquid form (dew). The maximum pressure is called saturation pressure and is temperature dependent. The temperature dependency is, however, not included in the term of absolute humidity.

Relative humidity

Relative humidity is the relationship between the actual water vapor pressure and the maximum possible water vapor pressure.

$$\%RH = 100 \cdot \frac{p}{ps}$$

%RH: Relative humidity percentage

p: Water vapor pressure in the gas mixture at ambient temperature

ps: Water vapor saturation pressure at ambient temperature

100% RH corresponds to the maximum amount of water vapor a gas mixture can contain at constant pressure and constant temperature. At constant water vapor partial pressure and changing ambient temperature the water vapor saturation pressure changes and consequently the relative humidity also changes (see water vapor saturation pressure).

To obtain useful measurements of relative humidity, it is extremely important that the measurement probe and measured medium have the same temperature.

Equilibrium relative humidity (ERH)

A hygroscopic material always tries to reach humidity equilibrium with the surrounding air. Equilibrium relative humidity is the free water content in a hygroscopic material after equilibrium is reached in an environment with constant relative humidity and temperature. Humidity equilibrium then prevails when the amount of water absorbed and desorbed is equal.

Water activity (aW)

Water activity is a measure of the freely available water in a material. Water activity is Equilibrium Relative Humidity divided by 100. The water activity value is an important indicator of the shelf life of food products, pharmaceuticals and other products and influences the incidence and propagation of micro-organisms.

Psychrometric parameters

Dew point / Frost point (Dp / Fp)

The dew point is the temperature at which the air over water is saturated with water vapor at a constant air pressure. The water vapor pressure that then prevails is the same as the water vapor saturation pressure.

Wet bulb temperature (Tw)

Is the lowest temperature that can be reached by evaporative cooling. The water given off by a wet surface is then in equilibrium with the water absorption capacity of the surrounding atmosphere.

Enthalpy (H)

Enthalpy of moist air is an energetic property. It is composed of the specific enthalpies of the components in the mixture (dry air, water vapor) and is related to the mass fraction of the dry air. It is given in J/kg.

Specific humidity (Q) in g/kg

The ratio of the mass of the water vapor to the mass of the complete gas mixture containing the water vapor.

Vapor concentration (Dv) in g/m3

The ratio of the mass of the water vapor to the volume of the complete gas mixture containing the water vapor.

Mixing ratio (R) in g/kg

The ratio of the mass of the water vapor to the mass of the dry gas mixture containing the water vapor.

Water vapor partial pressure (E) in hPa

The fraction of the total pressure of a gaseous mixture due to water vapor.

Water vapor saturation pressure (Ew) in hPa

The maximum pressure that water vapor can reach over a water surface at a given temperature.

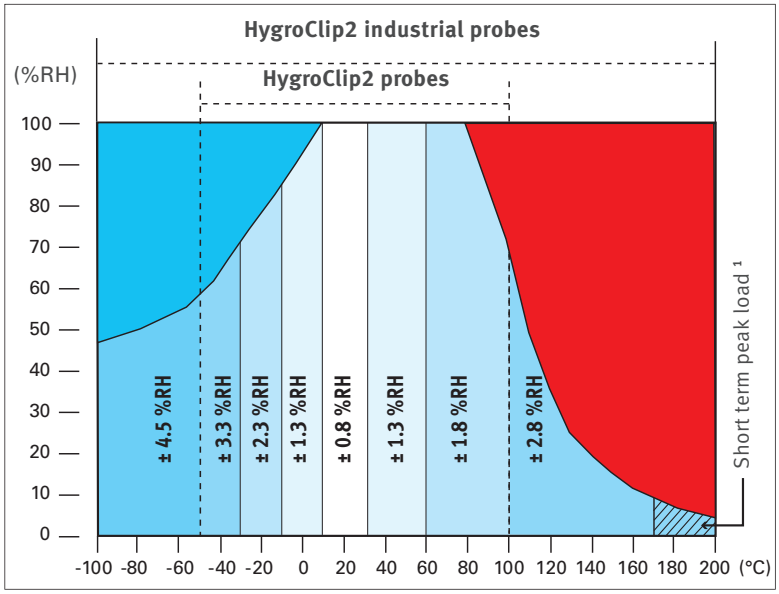
Response time of ROTRONIC sensors

ROTRONIC defines the response time of its sensors as the time taken to complete 63% of a step change in humidity. The response time becomes greater at low temperatures and little air movement. It also increases when a filter is used.

Accuracy of HC2 probes

The accuracy of the ROTRONIC humidity and temperature probes is highest at the adjustment points. HygroClip2 probes are adjusted according to international standards with a volume flow of 10 l/min. and 1 m/s at 23 ±5 °C. Depending on the product and adjustment profile, the accuracy ranges between ±0.5 %RH / 0.1 K and ±2.0 %RH / 0.3 K. The accuracies specified for our probes relate to our production plant reference probes traceable to the national standard.
Maximum accuracy is achieved when adjustment of the probes is at the point of use. ROTRONIC offers this service (see chapter Services, page 156).

Humidity



HygroClip2 industrial probes
HC2-IC1xx, HC2-IC3xx, HC2-IC4xx,
HC2-IC5xx, HC2-IC7xx
HC2-IC1xxA, HC2-IC3xx-A, HC2-IC4xxA,
HC2-IC5xxA, HC2-IC7xxA

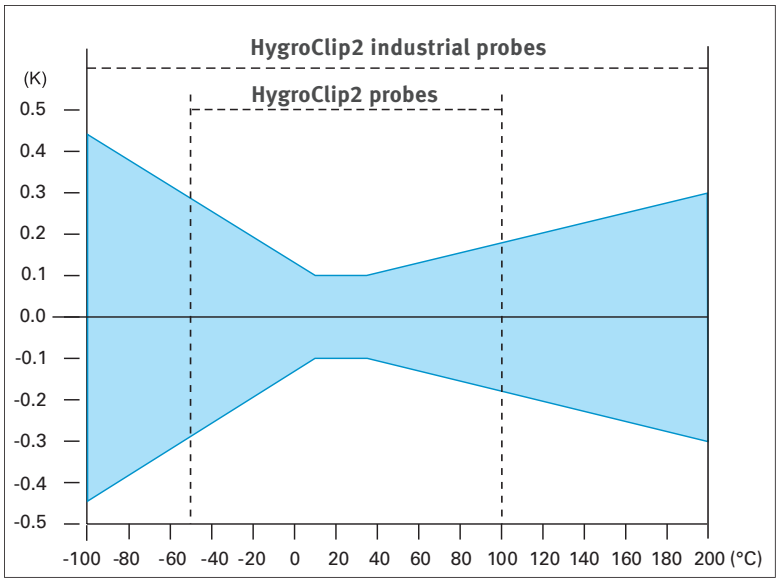
Accuracy of humidity measurements over the measuring range

HygroClip2 probes
HC2-S, HC2-S3, HC2-R, HC2-R3

Accuracy of humidity measurements over the measuring range

[1] **Short-term peak loads:**
Rotronic probes allow a peak load of 3x5 minutes at 200 °C without suffering any permanent damage. The time between the peak loads is of no importance. Longer peak loads can result in an increased sensor drift of up to 3 %RH over a 25 hours period.

Temperature



HygroClip2 industrial probes
HC2-IC1xx, HC2-IC3xx, HC2-IC4xx,
HC2-IC5xx, HC2-IC7xx
HC2-IC1xxA, HC2-IC3xx-A, HC2-IC4xxA,
HC2-IC5xxA, HC2-IC7xxA

Accuracy of temperature measurements over the measuring range

HygroClip2 probes
HC2-S, HC2-S3, HC2-R, HC2-R3

Accuracy of temperature measurements over the measuring range

Contaminants/Pollutants

Some gases and contaminants/pollutants can damage ROTRONIC humidity sensors. The contaminants/pollutants can be divided into two categories: gases without influence and gases with an influence on the humidity sensors.
For contaminants/pollutants with an influence on the sensors and therefore with an influence on the measurement result, the maximum constant concentration must be known (see table below).

Contaminants/Pollutants with an influence

		Max. constant concentration	
Substance	**Formula**	**ppm**	**mg/m³**
Ammonia	NH_3	5500	4000
Acetone	CH_3COCH_3	3300	8000
Gasoline			150000
Chlorine	Cl_2	0.7	2
Acetic acid	CH_3COOH	800	2000
Ethyl acetate	CH3COOC2H5	4000	15000
Ethanol	C_2H_5OH	3500	6000
Ethylene glycol	$HOCH_2CH2OH$	1200	3000
Formaldehyde	HCHO	2400	3000
Isopropanol	$(CH3)_2CHOH$	4800	12000
Methyl alcohol	CH_3OH	3500	6000
Methyl ethyl keton	$C_2H_5COCH_3$	3300	8000
Ozone	O_3	0.5	1
Hydrochloric acid	HCl	300	500
Hydrogen sulfide	H_2S	350	500
Nitrous gases	NOx	5	9
Sulfur dioxide	SO_2	5	13
Toluene/ Xylene	$C_6H_5CH_3$	1300	5000
Xylene	$C_6H_5(CH_3)_2$	1300	5000

Contaminants/Pollutants without influence

Substance	**Formula**
Argon	Ar
Helium	He
Hydrogen	H2
Neon	Ne
Nitrogen	N2
Oxygen	O2
Butane	C4H10
Ethane	C2H6
Methane	CH4
Natural gas	
Propane	C3H8

Note that the common sealing material silicon damages the sensor!
When probes are installed, silicon must not be used!

Probe use in practice

As a world-leading manufacturer of humidity measurement instruments, ROTRONIC is fully aware of its responsibility to offer instruments that can withstand the harshest operating conditions, while remaining user-friendly and requiring minimal maintenance. To achieve the best possible performance from our measurement instruments, we urge users to follow the guidelines outlined below.

1. Analyze the environment in which the humidity probe is used. What suspended substances and/or chemicals exist and in what concentration?
2. Install the probe at a place representative of the measured climate with good airflow across the sensor.
3. Choose the right filter. Measurement is fastest without a filter. For wind velocities higher than 3 m/s, however, a filter must be used. The filter protects the sensor up to airflow velocities of 40 m/s. Suitable filters must also be used when contaminants, pollutants and in harsh environmental conditions are present.
4. Install the probe correctly to suit the application.
5. Inspect and replace the filter more frequently in harsh operating conditions. Filters can be cleaned in an ultrasonic bath. However, always keep a new filter set in stock.
6. Check that the measurement probe is working correctly by performing a calibration at least every 6 to 12 months.
7. For calibration, use one of our calibration services or the SCS-certified humidity standards. This will ensure that you have calibration traceable to national standards.