



Relative humidity - Definitions - Physical laws

Humidity has always been an important part of life for people, fauna, flora and products. People realized at an early stage that humidity affects most substances, in particular living organisms. We experience relative humidity ourselves on a daily basis. We unknowingly apply its laws, for instance when we perspire and our sweat evaporates and is absorbed by the air, this only happens if the air can still absorb moisture. We benefit from the cold air which results from evaporation when there is an air-flow. When we have a sauna, we increase the temperature of the air so much that the air absorbs a lot of moisture.

Everyone is familiar with the sensation whereby the mucous membranes of the nose dry up when they are in heated rooms during the winter, placing them at risk of catching viral infections or the unpleasant sultry feeling that we experience in the prevailing high humidity during the summer. Relative humidity plays a major role, among others, in the feeling of comfort.

Nowadays, attention goes well beyond the comfort of people, focusing on the products and their compatibility with relative humidity. In production processes goods require the correct level of relative humidity, otherwise they lose their properties. We are thinking in particular here of paper which is hygroscopic and which causes problems if it is printed on under incorrect humidity conditions, or the storage of fruit and vegetables which start to shrink and ripen too early if they are stored in the wrong humidity conditions, in computer systems which switch off if the ambient air is too dry or too moist, with sausage and cheese, with the storage of steel, with the preservation of steel armour, with the drying of tobacco, the list is endless.

But what is relative humidity?

The composition of air:

- 78.1% by vol. nitrogen
- 20.93% by vol. oxygen
- 0.93% by vol. argon
- 0.03% by vol. carbon dioxide
- 0.01% by vol. hydrogen
- helium, neon, krypton, xenon in smaller quantities

This composition is called „**dry air**“ and occurs very rarely naturally.

„**Moist air**“ contains (visible or invisible) water vapour to a greater or a lesser extent. Where it is visible, it is mist.

Air, as dealt with in air-conditioning technology, can be regarded as an "ideal gas". Consequently, there is a prevailing "mix of water vapour and air", and, thus, "Dalton's laws of gases" apply.

The **total pressure** of the gas mixture comprises the partial pressures of the air and of the water vapour.

$$P = P_{\text{air}} + P_{\text{vapour}}$$

The **air pressure** is the total pressure which a vertical column of air exerts on its base at any location in the earth's atmosphere.

Air pressure is also referred to as the total pressure in sealed rooms which differs from the air pressure of the earth's atmosphere as a result of physical events.

The **partial pressure** is the portion of the pressure which is generated by a gas component contained in the atmosphere whereby this gas component is regarded as being present on its own in the atmosphere.

The **water vapour partial pressure** is the partial pressure of the water vapour contained in the atmosphere, i.e. in gaseous state.

The **air temperature** is a measure of the warmth of the air measured in °C.

The **relative humidity** is the ratio between the prevailing water vapour pressure and the water vapour saturation pressure in relation to water or ice at the same total pressure and at the same temperature

The relative humidity is a "dimensionless variable", it is a proportional number. However, the symbol %RH is often used. It frequently does not make sense to express this purely in numerical terms, e.g. 50%, because other variables have to be specified in percentage terms, e.g. manipulated variable of 50%. In order to avoid any misunderstanding, Galltec GmbH uses the expressions 50%rF or 50%RH.

The relative humidity is used to identify the humidity of the air and is determined by the following:

$$\frac{\text{actual mass of vapour in the air}}{\text{mass of vapour in the saturated air}} = \frac{m_D}{m_{D_s}}$$

$$\frac{\text{prevailing partial pressure of the water vapour}}{\text{saturation pressure of the water vapour}} = \frac{P_D}{P_{D_s}}$$

The **dew point temperature** is the temperature at which the air is saturated with water vapour at constant air pressure. In that case, the prevailing water vapour partial pressure is the same as the water vapour saturation pressure.

The dew point temperature, and thus the water vapour saturation pressure, of the moist air is achieved in that the moist air is cooled with temperature t without any change in pressure and moisture until the water vapour condenses at dew point temperature td. The dew point temperature is the same as the water vapour saturation temperature.

The **dew point temperature difference** is the difference between the temperature t and the dew point temperature of the moist air. The terms dew point difference and dew point gap are also used to refer to the dew point temperature difference.

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