Humidity Calibration-Basics

It is known and accepted that relative humidity is one of the physical quantities most difficult to calibrate.
The main problem is to generate humidity with high accuracy and stability especially for calibration outside a special humidity lab. There are different methods to generate humidity, whereby all classical methods require either temperature stability and uniformity or accurate measurement of the temperature.

Saturated Salt Solutions

A closed box partly filled with saturated salt solutions generates relative humidity in the free room above the salt with good accuracy. The value of the relative humidity depends on the type of salt used.
It is mainly independent of temperature, but strongly dependent on temperature uniformity. For an accuracy of ±2 %RH a temperature uniformity better than 0.5 degC is necessary.

Non Saturated Salt Solutions

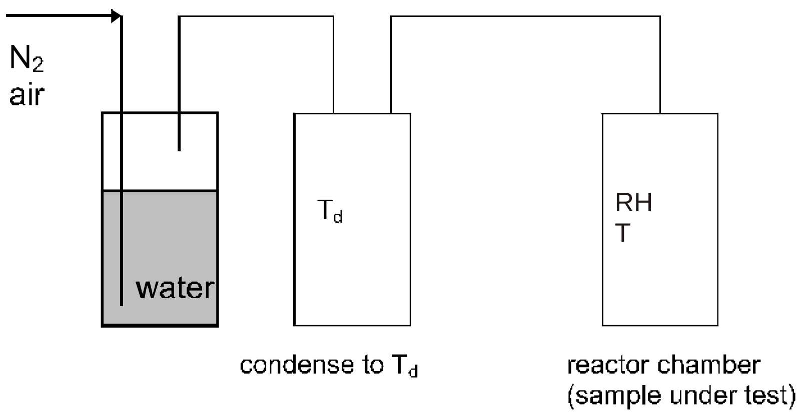
Instead of saturated salts non concentrated LiCl-solutions can be used. The obtained values of the rel. humidity depend on the salt concentration.

Mixing Reactor

A stream of dry air (0%RH) is splitted into two separated streams. One gas stream is saturated with vapour in a saturation chamber (100 %RH), the other one remains dry.
The RH in the measuring chamber is set by adjusting the mixing ratio of the two air streams with a mass flow controller.

Two-Temperature Reactor

Air or nitrogen is saturated with vapour in a saturation chamber and cooled down to the dew point temperature Td corresponding to the requested relative humidity RH at temperature T. Excess vapour condenses and the vapour partial pressure equals to the saturation partial pressure.
The saturated air warms up to temperature T, the vapour partial pressure corresponds to the required RH. (Principle of reverse dew point mirror)



In an idealy designed two-temperature-reactor the accuracy depends only on the measurement of two temperatures (T, Td).
Main disadvantage is a long stabilisation time when changing the humidity.

Two-Pressure Reactor

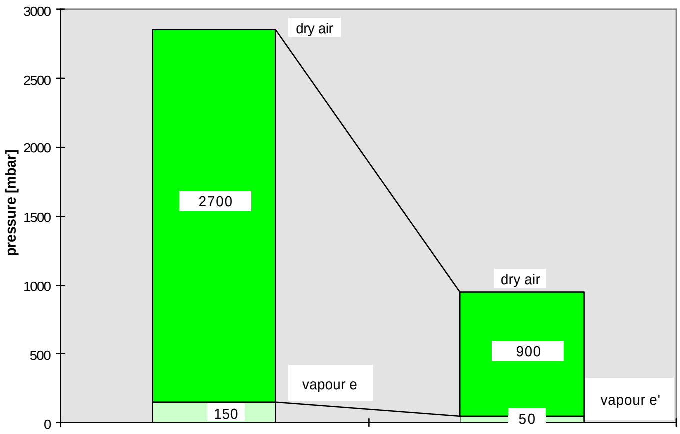
Air with a pressure **p1** consisting of dry air and a certain vapour pressure **e** is expanded to a pressure **p2**. During the expansion all components of the air will be expanded with the same ratio **p2/p1**, i.e. also the vapour pressure **e** is expanded.

Initial state :
total pressure **p1 = pda + e**

expanded state :
total pressure **p2 = p1 * p2/p1 = p2/p1 * (pda + e)**

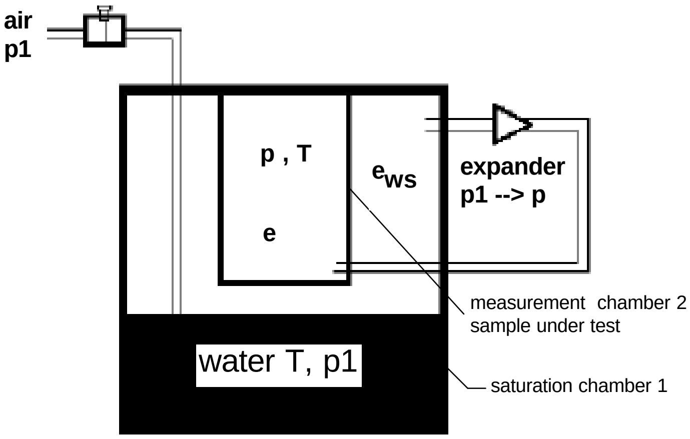
After expansion the vapour pressure of the moist air is reduced to

e' = p2/p1* e



Two-Pressure Humidity Calibrator HUMOR 10/10S

The two pressure humidity calibrator HUMOR 10 / 10S consists of two chambers, one built within the other.



Shematic construction of the two pressure reactor HUMOR 10

Air or nitrogen with a pressure **p1** is saturated in the saturation chamber 1. The vapor partial pressure $\mathbf{e_{ws}}$ is maximum, the RH is 100%.
Then the saturated air is expanded to the ambient pressure **p** in the measuring chamber 2. The saturation and measuring chambers of HUMOR 10 are built one inside the other and are made from materials with high thermal conductivity. These assures uniform temperature in both chambers.
Under these conditions the partial pressure of vapors is reduced in the same ratio as the total pressure of air and becomes:

$$e = e_{ws} * p/p1$$

Consequently $\mathbf{RH = e/e_{ws} = p/p1}$

The generated RH depends only on the ratio of two pressures, which allows a very short stabilisation time. The RH in the measurement chamber is set to the desired value by adjusting the inlet pressure **p1**.
The saturated partial pressure $\mathbf{e_{ws}}$ depends slightly on pressure. The correction is made by a microprocessor.
Practically the generated humidity is calculated from the pressures measured by two pressure sensors with excellent long term stability and reproducibility.