RELATIVE HUMIDITY: MEASURING WITH A DEWPOINT HYGROMETER

Key words: Moisture, temperature, dewpoint, relative humidity, dewpoint hygrometer

1. SCOPE
This test method is used for measurement of the moisture content of air by determination of the dewpoint temperature, using a dewpoint hygrometer. The results may be recalculated and expressed as the total moisture content of the air or as partial water vapour pressure. If the air temperature is measured at the same time, the method can be used for determination of the relative humidity of the air.

2. FIELD OF APPLICATION
Dewpoint hygrometers are used for measurement of the dewpoint temperature of ambient air. As most dewpoint hygrometers have good accuracy, they are often used as references (normals) for calibration of other instruments. If the air temperature is measured simultaneously with the dewpoint temperature, then the relative humidity can be calculated. The method can be used for determination of the relative humidity of air in equilibrium with the pores of building materials stored in a closed air volume.

Some instruments have a probe, with the sensor element being mounted in an open enclosure in such a way as to allow air to diffuse inside to the sensor. Probes of this kind are often sufficiently small to allow them to be placed inside confined spaces, such as drillholes. Some instruments have a probe with a sealed enclosure to which tubes are connected, with air being brought to the sensor by a small pump. Both methods can be used to measure the humidity of various building materials on site, as well as that of samples maintained in closed air volumes.

Long-term measurements can be made by most instruments: the maximum sampling rate varies for different instruments between 5 and 50 samples/hour.

3. REFERENCES
None.

4. DEFINITIONS
Vapour concentration of air, \(v\) [kg/m\(^3\)] is the ratio of the mass of water vapour to the total volume of the moist air.

Partial water vapour pressure, \(p\) [Pa] is the product of the mole fraction of water vapour in the moist air and the total pressure at the temperature of the air.

Saturation vapour concentration of air, \(v_s\) [kg/m\(^3\)] is the vapour concentration in equilibrium with a plane surface of liquid water. \(v_s\) is a function of temperature.

Saturation water vapour pressure, \(p_s\) [Pa] is the pressure of water vapour in equilibrium with a plane surface of liquid water. \(p_s\) is a function of temperature.

Relative humidity, \(\varphi\) or (RH) of air is the ratio between the actual partial water vapour pressure and the saturation water vapour pressure at the temperature of the air (equal to the ratio between the actual vapour concentration and the saturation vapour concentration of the air), i.e.

\[
\varphi = \frac{p}{p_s} = \frac{v}{v_s}
\]

Dewpoint or dewpoint temperature, \(T_s\) [°C or K], is the temperature to which air with a given vapour concentration must be cooled before moisture starts to condense into water droplets (dew). When the temperature of the air is the same as the dewpoint temperature, its vapour concentration is the same as the saturation point vapour concentration.

5. SAMPLING
Not relevant.

6. TEST METHOD
6.1 Principle
The principle of the dewpoint hygrometer involves air flowing over a small cooled surface. The temperature of this surface is reduced until moisture starts to condense on it, after which its temperature is raised until all the condensed moisture has been evaporated and returned to the air. This process is repeated until the instrument has determined the temperature of the surface at which condensation just occurs.

In order to be able to determine whether or not the cooled surface is covered with condensate, it is designed as a mirror. A light source is aimed at the mirror, and the reflected light is registered by a light detector. When the mirror is free of condensation, the light is reflected sharply and with high intensity. As condensation forms on the mirror, the water droplets diffuse the reflection, so that the intensity of the light on the detector is reduced.
6.2 Apparatus

The sensor (measuring chamber) of a dewpoint hygrometer consists of a mirror, an optical system for registering condensation on the mirror and a system for control and registration of the mirror temperature. The mirror is heated and cooled by Peltier elements. The temperature is measured using an electrical resistance sensor. The mirror, the Peltier element and the temperature sensor are built together in a single unit. A light source and a light detector are fitted adjacent to the mirror. The electronic equipment that controls the instrument is normally mounted in a separate display unit, where the dewpoint temperature can be read out. The unit often incorporates an analogue or digital output which can be used for long-term data logging of the dewpoint temperature.

The instrument probe can be of various types, with two different types being distinguishable. Some probes have an open measuring chamber, into which air diffuses passively. These probes may be fitted with filters as protection against dirt. The second type has a closed measurement chamber, with air being supplied to it by a pump through hoses. The air may often be recirculated in a closed loop.

6.3 Preparation

6.3.1 Ambient air

When making measurements of ambient air conditions, the instrument must be positioned so that the point at which it makes its measurements can be assumed to be representative of the room. Absolute vapour concentration does not normally vary very much from point to point within a room, but the instrument should not be placed close to cold surfaces or in the vicinity of ventilation air inlets. It must be protected against dirt and physical damage, which can both cause incorrect readings.

6.3.2 Enclosed spaces

The instrument’s sensor is often sufficiently small to allow it to be placed inside spaces in which relative humidity or vapour concentration are to be measured. This facility can be used, for example, for measuring the vapour concentration in drillholes in concrete.

Note: Selection of a representative sampling position, number of measurement points etc. are not considered in this method.

Instruments having a probe with an enclosed sheath make their measurements by conducting the air in small hoses from the enclosed air volume to the instrument. The air is normally recirculated in a closed cycle. Some instruments incorporate their own circulation pump. The temperature of the hoses and instrument should be approximately the same as that of the enclosed air volume, in order to prevent condensation in the system. An appropriate air flow rate or permissible pressure drop are normally defined in the instrument instructions.

When making measurements in drilled holes in concrete, the heat generated by drilling the hole will have affected the natural moisture equilibrium in the material. Initial values recorded by the instrument will be too high. Measurements should therefore not be made for 2-6 days after drilling the hole. Holes must be thoroughly cleaned and sealed until the measurements are made. The measurement time is 1-24 hours, depending on the accuracy required and on whether special liner tubes are used.

Note: Where the objective of the measurement is to investigate whether the concrete slab is dry, and low values are obtained after only two days, this may be sufficient information. In other cases, a longer period of time should elapse between drilling and measuring.

6.3.3 Measurement of samples

When taking samples of materials for subsequent measurement of moisture content, the samples must be stored in closed containers to prevent exchange of moisture with their surroundings. The natural temperature of the samples must be measured and noted before taking the samples.

Note: Selection of a representative sampling position, number of measurement points etc. are not considered in this method.

6.4 Procedure

6.4.1 General

Check the mirror before use and clean it. Cleaning needs to be repeated relatively frequently (= days or weeks, depending on use). The instrument’s instructions will indicate suitable cleaning fluids. In other respects, most dewpoint hygrometers are very easy to use.

Calibration need to be carried out only at relatively long intervals (= months or years, depending on use), and should be carried out by an accredited laboratory.

In large air volumes, the measuring time is about one minute. When measuring the air in drillholes, or from samples of material, the measurement time in practice may be 1-24 hours, depending on the length of time necessary for the air and material to reach moisture equilibrium.

Note: The probe must be reasonably close to thermal equilibrium with its surroundings. When it is cold, relative to the air under investigation, moisture may unintentionally condense on the cold surfaces, resulting in incorrect measurements.

6.4.2 Measurement of samples

Before making the measurements, place the material samples in a small enclosed air volume, the temperature of which should be the same as that of the material from which the samples were taken. Connect the dewpoint hygrometer either directly or via a hose to form a closed system. Measurements can be made when the air volume has reached equilibrium conditions with the material sample, which can normally take up to 24 hours.

The temperature of the sample should be the same as that of the material from which it was taken. Where high accuracy is required, the measured results must be corrected for any temperature difference between the temperature at the time of taking the sample and the temperature when making the measurements. Both the air temperature and the dewpoint must be measured if relative humidity is to be determined.
6.5 Expression of results
Express the results either directly as a dewpoint temperature or converted to absolute vapour concentration (or to partial pressure of the water vapour) in the air. If the air temperature has been measured at the same time as the dewpoint temperature, the relative humidity at the time can be calculated.

6.6 Accuracy
Measurement inaccuracy when determining dewpoint temperature is generally better than ± 0.5 °C.

Note: When converting the results to relative humidity, a variation of ±0.5 °C in the dewpoint temperature determination represents a variation of about ±1.5 % RH at 20 °C and 95 % RH, or about ±3 % RH at 20 °C and 50 % RH.

6.7 Test report
The test report shall include the following information, if relevant:
a) Name and address of the testing laboratory
b) Identification number of the test report
c) Name and address of the organisation or person ordering the test
d) Purpose of the test
e) Method of sampling, choice of measuring points and other conditions (date and person responsible for sampling)
f) Address of the building in which the measurements were made, or other identification of the tested items.
g) A detailed description of the place where the measurements were made, or a description of the tested items
h) The date of supply of the tested items, and the date when the measurements were ordered
i) The date of making the measurements
j) The test method
k) Conditioning of the test specimens, environmental conditions during the test (temperature, RH etc.)
l) Identification of the instrument used for measurement (product, model and laboratory inventory number, calibration status)
m) Any deviation from the test method
n) Results of the measurements
o) Inaccuracy or uncertainty of the measurements
p) Date and signature.