SLOVENSKI STANDARD
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Ohranjanje kulturne dediščine - Postopki in instrumenti za merjenje vlažnosti v zraku in izmenjave vlage med zrakom in kulturno dediščino

Conservation of cultural property - Procedures and instruments for measuring humidity in the air and moisture exchanges between air and cultural property

Erhaltung des kulturellen Erbes - Verfahren und Geräte zur Messung der Luftfeuchte und des Feuchtigkeitsaustausches zwischen Luft und Kulturgut

Conservation des biens culturels - Modes opératoires et instruments de mesure de l'humidité de l'air et des échanges d'humidité entre l'air et les biens culturels

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Conservation of cultural heritage - Procedures and instruments for measuring humidity in the air and moisture exchanges between air and cultural property

Conservation des biens culturels - Modes opératoires et instruments de mesure de l'humidité de l'air et des échanges d'humidité entre l'air et les biens culturels

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Contents

Foreword

This document (EN 16242:2012) has been prepared by Technical Committee CEN/TC 346 “Conservation of cultural heritage”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2013, and conflicting national standards shall be withdrawn at the latest by May 2013.

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Introduction

Humidity plays a key role in the conservation of cultural heritage because most materials and/or deterioration mechanisms are directly or indirectly affected by humidity levels or changes. This European Standard is a guide intended to assist in providing an acceptable environment for cultural heritage objects. Humidity in air, expressed in a number of ways, is an important aspect of that environment. Therefore, the control of levels and variability of humidity reduces the risk of deterioration and is an important preventive measure, minimising the need for future conservation interventions.

This European Standard is a guide to specifying adequate procedures for measuring humidity in air and the minimum characteristics of instruments for such measurements so that they are carried out to an appropriate level of accuracy. Although standards exist for measuring humidity in air in other fields like meteorology or ergonomics of thermal environments, this standard focuses on the specific requirements of cultural objects.

This document is one of the series of European Standards intended for use in the study of environments for cultural property.

1 Scope

This European Standard gives guidance and specifies procedures and instruments for the measurement of relative humidity (RH) in air, in outdoor or indoor environments. It indicates how RH can be directly measured or how it can be calculated from air temperature, wet-bulb temperature and dew-point temperature. This standard contains recommendations for accurate measurements of ambient conditions and moisture exchanges between air and cultural heritage objects. It is addressed to anyone in charge of environmental diagnosis, conservation or maintenance of buildings, collections or single objects.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 15757:2010, *Conservation of Cultural Property - Specifications for temperature and relative humidity to limit climate-induced mechanical damage in organic hygroscopic materials*

EN 15758:2010, *Conservation of Cultural Property - Procedures and instruments for measuring temperatures of the air and of the surfaces of objects*

EN 60751, *Industrial platinum resistance thermometers and platinum temperature sensors (IEC 60751)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*

ISO/IEC Guide 98-3 *Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15758:2010 and the following apply.

3.1
absolute humidity *(AH)*

volume density of water vapour, i.e. the mass of vapour contained in the unit volume of moist air $AH = \frac{m_v}{V}$, expressed in g/m^3

Note 1 to entry: This volume density is also noted ρv (v for volume)

3.2
atmospheric (or barometric) pressure *(p)*
pressure is the force per unit area exerted by the air column above the measuring point, expressed in hPa (hectopascal)

Note 1 to entry: 1 hPa = 1 mbar (millibar)

3.3
barometer
instrument for measuring atmospheric pressure

3.4
dew-point hygrometer
instrument for measuring the temperature at which a cooled parcel of air becomes saturated with water vapour

3.5
dew-point temperature *(DP)*
temperature to which air is cooled at constant pressure and constant water vapour content in order for saturation to occur

Note 1 to entry: This is expressed in degrees Celsius (°C). [EN 15758: 2010]

3.6
dry air
atmospheric air without water vapour

3.7
dry-bulb temperature *(T, t)*
actual air temperature. In a *psychrometer*, the temperature reached by the thermometer having the dry bulb

Note 1 to entry: Capital *T* is used when the measurement is expressed in Kelvin (K); lowercase *t* when expressed in degrees Celsius (°C).

3.8
equilibrium moisture content *(EMC)*
moisture content at which a material neither loses nor gains moisture from the surrounding atmosphere at given relative humidity and temperature levels. Expressed in g/kg as the ratio of the mass of water m_w contained in the material and the dry mass m_{dm} of the same material, i.e.: $EMC = \frac{m_w}{m_{dm}}$

3.9
frost-point temperature
temperature to which moist air must be cooled, at constant pressure and humidity mixing ratio, in order that it shall be saturated with respect to ice, expressed in degrees Celsius (°C)

3.10
hygrograph
instrument for measuring relative humidity (see hygrometer) and recording over time

Note 1 to entry: Generally, a mechanically or electrically driven drum supporting a strip chart with RH graduation where an ink pen traces a time plot of the ambient humidity.

3.11
hygrometer
instrument measuring relative humidity

Note 1 to entry: It generally comprises a sensor, which is set in equilibrium with the air, and a system that transforms the signal from the sensor into humidity readings.

3.12
mixing ratio or humidity mixing ratio *(MR)*

ratio of the mass of water vapour m_v to the mass of dry air ma, i.e. $MR = \frac{m_v}{m_a}$, expressed in g/kg

3.13
moist air
mixture of dry air and water vapour

3.14
psychrometer
instrument for measuring the dry- and wet-bulb temperatures to calculate relative humidity and other related variables

Note 1 to entry: It consists of two identical thermometers, one of which is sheathed in wet wicking, and a fan to ensure their ventilation at a constant velocity in order to reach equilibrium with air. Thermometer readings are expressed in degrees Celsius (°C). Some electronic instruments provide readings of relative humidity (%), dew point (°C) and other related variables.

3.15
relative humidity *(RH)*
ratio of the actual vapour pressure of the air to the saturation vapour pressure

[SOURCE: EN 15757:2010]

3.16
measuring range
interval of values that are intended to be measured, or that are potentially measurable, or that have been measured, specified by their upper and lower limits

3.17
repeatability
ability of the measuring instrument to reproduce the same output when successively measuring the same value of the air or the surface under investigation, taken under the same conditions

Note 1 to entry: This is expressed as ± percent of the range.

[SOURCE: EN 15758:2010]

3.18
resolution
smallest difference between indications of a displaying device that can be meaningfully distinguished

3.19
response time
time interval between the instant when the parameter under investigation is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits around its final steady value

Note 1 to entry: The response time is typically expressed as the time needed to reach 63,2 % of the final value and in this case is called time constant, or 90 % or 95 % of it. The 90 % response time is 2,3 times longer than the time constant and the 95 % response time is three times longer. The response time is independent of the span of the output change.

[SOURCE: EN 15758:2010]

3.20
saturation vapour pressure ($e_{sat}(t)$)
maximum pressure of the water vapour in equilibrium with plane surface of pure water, expressed in hPa (hectopascal)

3.21
sensor
device that senses either an absolute value or a change in a physical quantity and converts them into a useful signal for an information-gathering system

3.22
thermometer
instrument to measure temperature which comprises a sensor which is placed in thermal equilibrium with the air (if it measures the air temperature) or the surface, sometimes a probe that contains and protects the sensor, and a system that transforms the input from the sensor into an output expressed in degrees Celsius (°C)

[SOURCE: EN 15758:2010]

3.23
time constant
time interval between the instant when the air, or the surface temperature, is subjected to a specified abrupt change and the instant when the response reaches (1 – 1/e) x 100 = 63,2 % and remains within specified limits around its final steady value

Note 1 to entry: See also response time.

[SOURCE: EN 15758:2010]

3.24
time stability
rate at which characteristics change in the course of time

Note 1 to entry: It is often expressed in terms of a percent change of the response per year (% / year).

3.25
surface temperature ***(t_s)***
temperature of a given surface of an object

Note 1 to entry: This can be measured with contact thermometers, quasi-contact total radiation thermometers or remote infrared thermometers. The surface temperature is generally different from the air temperature, and varies between different objects and different places on the same object. It is expressed in degrees Celsius (°C). In general, the measured surface temperature is not representative of the whole object.

[SOURCE: EN 15758:2010]

3.26
uncertainty (of measurement)
uncertainty is a non-negative parameter characterising the dispersion of the values attributed to a measured quantity

[SOURCE: EN 15758:2010]

3.27
wet-bulb temperature ***(t_w)***
in a psychrometer, the temperature reached by a thermometer sheathed in wet wicking, expressed in degrees Celsius (°C)

4 Quantities characterising humidity in air

4.1 General

Air humidity is expressed in a number of ways. In this standard, we refer to four key quantities characterising humidity in air for the purposes of environmental diagnosis to preserve cultural heritage: relative humidity, humidity mixing ratio, absolute humidity and dew-point temperature.

4.2 Relative humidity

Relative humidity (RH) is responsible for, or related to, many deterioration mechanisms affecting cultural property preservation. Dry environments become dusty and electrostatic deposition is enhanced. Humid environments increase chemical reactivity of gaseous pollutants. Hygroscopic materials, such as wood, paper, textiles, leather or bone, absorb and release moisture in response to changes in RH, reaching eventually at a given temperature and RH a constant level of moisture termed Equilibrium Moisture Content (EMC). The variations in EMC produce dimensional changes of the materials, i.e. expansion when EMC is increasing and shrinkage when decreasing, which may lead to high levels of stress and physical damage as fracture and deformation. High EMC favours mould growth, as well as hydrolysis, oxidation, corrosion or other chemical reactions.

RH has a synergic effect with light, temperature, pollution and other environmental factors in accelerating fading, discoloration and embrittlement.

4.3 The humidity mixing ratio

The humidity mixing ratio (MR) is used to distinguish if water molecules are added to or removed from the atmosphere, e.g. to monitor evaporation, condensation, or mixing of two air masses. It is useful for environmental diagnostic purposes, to provide evidence of the action of heating, ventilation and air-conditioning systems (HVAC systems) or air-surface interactions. By measuring this parameter along a horizontal cross-section of a room, it is possible to reveal external air penetrating through openings, or moisture released by visitors, or when and where masonry is evaporating (higher MR close to the wall) or adsorbing moisture (lower MR to the wall).

4.4 Absolute humidity

The absolute humidity (AH) is useful in assessing the maximum quantity of water vapour that a given volume can contain at specified temperature conditions. When AH exceeds the saturation level in the air, the excess moisture will condense. From the knowledge of the volume of a closed space, it is possible to calculate how much water will condense on objects and masonry. Such information can be used to determine, e.g., the maximum allowable number of visitors in a closed room, in order to avoid high humidity levels.

4.5 Dew-point temperature

When the dew-point (DP) of the air is compared with the surface temperature (T_S) of a structure or an object, the potential risk of water vapour condensation on that surface can be evaluated, i.e. condensation occurs if T_S is below DP and does not occur if T_S is above DP.

Formulae to calculate the above quantities are reported in Annex A. Examples of environmental diagnosis using these quantities are reported in Annex B.

5 Considerations and recommendations related to measuring methods

5.1 Considerations

An accurate determination of relative humidity (RH) requires particular care because the measurement depends on the temperatures of the air and the instrument, which should be in equilibrium with each other.

Recommendations described in EN 15757 should be considered in the frame of this standard. They should also be considered in the frame of a specific monitoring campaign that contains not only the quantity but also the thermal and/or humidity fields in the surrounding environment as well as close to the object.

The locations of the measuring points should be selected in such a way that they are representative of the environment under investigation. Each room generally shows variations of temperature and RH from point to point, therefore temperature and RH of the air that interacts with the object should be measured at a close distance to the surface. RH should be measured also in free air, i.e. in a location not affected by the surface (preferably, at a one metre distance or in the middle of the room). From these two measurements, it is possible to establish whether the surface is exchanging moisture with air or not.

If the surface temperature is different from the air temperature, the air layer in contact with the surface reaches a different RH from the air around the object, which is difficult to measure. The actual RH at the interface between air and surface should be calculated from the actual surface temperature and the humidity mixing ratio of the air in the proximity, the latter to be derived from the values of air temperature and RH or wet-bulb or dew-point temperatures. In the case some parts of the building (especially external walls) have a different temperature, a number of RH measurements should be performed in order to document how RH changes over the room/building.

Measurements in locations affected by disturbing factors such as heaters, ventilation grilles, windows or doors, or surfaces having a different temperature should be avoided. The measuring instruments should be placed at the level of the object if air stratification is present.

If the instrument temperature is different from the air temperature the RH readings are affected by error. The problem of thermal inertia shall be reduced by using sensors externally connected to the measuring instrument.

Relative humidity can either be measured by means of sensors whose output is directly RH related, or calculated from measurement of the air temperature in combination with the dew-point or the wet-bulb temperature. In the latter case, atmospheric pressure shall be taken into account, in particular for measurements performed in the mountains at high altitudes.

5.2 Recommendations

In the scope of this European Standard, the following recommendations apply:

- the dew-point meter is recommended in the laboratory as a reference instrument to calibrate other hygrometers;

- the electronic psychrometer is recommended for on-site checking the calibration of other hygrometers and/or for spot measurements;
- the capacitive and/or the resistive electronic hygrometers are recommended for spot or routine measurements and/or data collection for statistical analysis;
- hair hygrometers/hygrographs should only be considered in exceptional circumstances for visual inspections.

The characteristics required for instruments or systems that measure air humidity are summarised in Table 1. This does not relate to sensors, which are considered separately. These characteristics are minimum requirements for the recommended use. Any measuring system that meets or exceeds the requirements of this European Standard can be used.

The response time of an RH hygrometer shall be considered. Meaningful results can be obtained after the sensor attains the equilibrium with the given temperature and relative humidity, which requires a time period of approximately twice the response time. If the probe is likely to be exposed to solar radiation, intense light illumination or infrared radiation from heaters, it should be shielded.

Qualified personnel should be aware of recommended measuring procedures and should use calibrated instruments that meet the characteristics set out in Table 1.