
Ohranjanje kulturne dediščine - Navodilo za merjenje vsebnosti vlage v materialih sestavov premične in nepremične kulturne dediščine

Conservation of Cultural Heritage - Guide to the measurements of moisture content in materials constituting movable and immovable cultural heritage

Erhaltung des kulturellen Erbes - Leitfaden zu Messungen des Feuchtegehalts in Materialien des beweglichen und unbeweglichen kulturellen Erbes

Conservation du patrimoine culturel - Guide relatif aux mesures de la teneur en eau de matériaux constituant un patrimoine culturel matériel et immatériel

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EUROPEAN STANDARD
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**Conservation of cultural heritage - Methods of
measurement of moisture content, or water content, in
materials constituting immovable cultural heritage**

Conservation du patrimoine culturel - Méthodes de
mesurage de la teneur en humidité, ou teneur en eau,
de matériaux constituant un patrimoine culturel
immatériel

Erhaltung des kulturellen Erbes - Verfahren zur
Bestimmung des Feuchte- bzw. Wassergehalts in
Materialien des unbeweglichen kulturellen Erbes

This European Standard was approved by CEN on 25 December 2016.

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European foreword

This document (EN 16682:2017) 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of an identical text or by endorsement, at the latest by September 2017, and conflicting national standards shall be withdrawn at the latest by September 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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Introduction

The specific field of cultural heritage is characterized by particular needs and in most cases the existing standards devised for normal materials cannot be applied. The moisture content, or the water content, in materials is of primary relevance for the preservation of cultural heritage. High content can be very damaging (e.g. salt dissolution and mobilization, fungal infestation, corrosion, swelling) as well as low content (e.g. salt crystallization, shrinkage, wood cracking) or alternating high/low content. It is therefore important to determine and control this variable to assess the risk of damage and take preventive conservation measures.

Different methods exist to measure moisture content, or water content, in modern building materials, based on different physical or chemical principles but most of them are not applicable to cultural heritage and need to be adapted to this aim.

Generally, non-destructive methods are recommended but their accuracy may be limited. In turn, the most accurate methods require sampling and can only exceptionally be used. Readings taken with non-destructive methods may not be comparable especially because they are expressed in different units. The interpretation of measurements may be obscured by a number of factors (e.g. material, salts, temperature) to which the methods are subject.

This European Standard considers and specifies characteristics, operative methodologies, pros and cons of all methods of measurements and establishes a uniform presentation of data and units. It is addressed to anyone who needs to measure or interpret readings of moisture content, or water content, in building materials (particularly masonry and wood), and in general to whoever is responsible for the preservation and maintenance of heritage buildings.

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1 Scope

This European Standard is aimed to inform and assist users in the choice and use of the most appropriate method to obtain reliable measurements of the moisture content, or water content, in wood and masonry (including brickwork, stonework, concrete, gypsum, mortars, etc.) in the specific case of the built cultural heritage.

It provides a basic framework to take and interpret this kind of measurements on the above cultural heritage materials that have undergone weathering, pest attack, salt migration or other transformations over time.

It specifies four absolute methods (i.e. gravimetric, Karl Fischer titration, azeotropic distillation and calcium carbide); explains their characteristics, pros and cons, and gives specifications for the transformation of readings into the same unit to make measurements taken with different methods comparable.

It specifies the three principal relative methods (i.e. electrical resistance, capacitance, and relative humidity in equilibrium with the material), pointing out their characteristics and uncertainties when used in the field of cultural heritage.

In addition, it provides an informative overview of ten other relative methods, their characteristics, pros and cons.

It gives specifications for the calibration of the various methods. It also compares the above methods in relation to their accuracy, sampling requirement, sample size, laboratory or field use, and other problems encountered in the field of cultural heritage to prevent instrument misuse, reduce uncertainties and avoid reading misinterpretation.

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 ISO 374-1, *Protective gloves against chemicals and micro-organisms - Part 1: Terminology and performance requirements*

EN 420:2003+A1:2009, *Protective gloves - General requirements and test methods*

EN 455-1:2000, *Medical gloves for single use - Part 1: Requirements and testing for freedom from holes*

EN 772-10:1999, *Methods of test for masonry units - Part 10: Determination of moisture content of calcium silicate and autoclaved aerated concrete units*

EN 837-1:1996, *Pressure gauges - Part 1: Bourdon tube pressure gauges - Dimensions, metrology, requirements and testing*

EN 1428:2012, *Bitumen and bituminous binders - Determination of water content in bituminous emulsions - Azeotropic distillation method*

EN 13183-1:2002, *Moisture content of a piece of sawn timber - Part 1: Determination by oven dry method*

EN 13183-2:2002, *Moisture content of a piece of sawn timber - Part 2: Estimation by electrical resistance method*

EN 13183-3:2005, *Moisture content of a piece of sawn timber - Part 3: Estimation by capacitance method*

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

EN 15898:2011, *Conservation of cultural property - Main general terms and definitions*

EN 16085:2012, *Conservation of Cultural property - Methodology for sampling from materials of cultural property - General rules*

EN 16096:2012, *Conservation of cultural property - Condition survey and report of built cultural heritage*

EN 16242:2012, *Conservation of cultural heritage - Procedures and instruments for measuring humidity in the air and moisture exchanges between air and cultural property*

EN ISO 10304-1:2009, *Water quality - Determination of dissolved anions by liquid chromatography of ions - Part 1: Determination of bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate (ISO 10304-1:2007)*

EN ISO 11461:2014, *Soil quality - Determination of soil water content as a volume fraction using coring sleeves - Gravimetric method (ISO 11461:2001)*

EN ISO 13130:2011, *Laboratory glassware - Desiccators (ISO 13130:2011)*

EN ISO 14911:1999, *Water quality - Determination of dissolved Li⁺, Na⁺, NH₄⁺, K⁺, Mn²⁺, Ca²⁺, Mg²⁺, Sr²⁺ and Ba²⁺ using ion chromatography - Method for water and waste water (ISO 14911:1998)*

EN ISO 15512, *Plastics - Determination of water content (ISO 15512)*

ISO 760:1978, *Determination of water — Karl Fischer method (General method)*

ISO 3567:2011, *Vacuum gauges — Calibration by direct comparison with a reference gauge*

ISO 5272:1979, *Toluene for industrial use — Specifications*

ISO 5280:1979, *Xylene for industrial use — Specification*

ISO 7183:2007, *Compressed-air dryers — Specifications and testing*

ISO 11465:1993, *Soil quality — Determination of dry matter and water content on a mass basis — Gravimetric method*

ISO 16979:2003, *Wood-based panels — Determination of moisture content*

ISO Guide 34:2009, *General requirements for the competence of reference material producers*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

EN ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15898:2011 and the following apply.

3.1**absolute method/measurement**

measuring method whose readings can be expressed in terms of SI units

3.2**active sensor**

sensor that needs some electrical power supply to operate

3.3**atmospheric pressure****barometric pressure**

pressure is the force per unit area exerted by the air column above the measuring point

Note 1 to entry: This is expressed in hPa (hectopascal).

[SOURCE: EN 16242:2012, 3.2]

3.4**bound water**

in masonry: water molecules physically or chemically bound to the material; bound water cannot dissolve soluble substances. In wood: water bonded in the cell walls; it is responsible for shrinkage/swelling

3.5**crystallization water****hydration water**

water molecules that are part of a hydrated crystal or molecule

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3.6**desiccator**

equipment in which a desiccant is used to maintain the air as close as possible to the absolutely dry condition

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[SOURCE: EN 322:1993, 4.3]

3.7**desiccant drying**

method in which drying is obtained with a continuous flow of dry air (from compressed air), or with moisture absorption from a highly hygroscopic substance used as desiccant

[SOURCE: EN 322:1993, 4.3]

3.8**destructive**

causing destruction or damage to cultural heritage materials

3.9**dew-point hygrometer**

instrument for measuring the temperature at which a cooled parcel of air becomes saturated with water vapour

[SOURCE: EN 16242:2012, 3.4]

EN 16682:2017 (E)**3.10****dew-point temperature**

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).

[SOURCE: EN 15758:2010, 3.6]

3.11**dry air**

atmospheric air without water vapour

[SOURCE: EN 16242:2012, 3.6]

3.12**dry matter**

whole of the substances which do not volatilize under the conditions of drying specified in this standard

[SOURCE: ISO 1026:1982, 2.1]

3.13**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

Note 1 to entry: This is expressed in g/kg as the ratio of the mass of water contained in the material and the dry mass of the same material.

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[SOURCE: EN 16242:2012, 3.8]

3.14**external sealed box****ESB**

box with five thermally insulating and impermeable faces and one missing face, fixed to the surface of a material to create an air pocket in hygrometric equilibrium with the material

3.15**fibre saturation point**

moisture content at which no free water is present in wood, while the cell walls are saturated with bound water

3.16**free water**

in masonry: liquid water inside pores. In wood: water contained in the cell cavities. It can dissolve soluble substances

3.17**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.

[SOURCE: EN 16242:2012, 3.11]

3.18**invasive**

requiring the entry of a probe, or other instrument into a cultural heritage material, for diagnostic purposes

3.19**irreversible relative humidity sensor**

sensor in which reached relative humidity levels remain permanently marked

3.20**minimally destructive****minimally invasive**

damage caused, or the sample taken, are very small and not easily recognizable, so that it can be considered acceptable, or justified in view of the advantages expected from the analysis

3.21**moisture content****MC**

amount of water in the material, as determined in accordance with a gravimetric method specified in this European Standard; the method may include the volatile organic compounds that may be lost when the material is heated at moderate temperatures

Note 1 to entry: The MC is expressed as a mass fraction in percent (%).

3.22**oven drying**

drying method obtained with a ventilated oven at temperature $103^{\circ}\text{C} \pm 2^{\circ}\text{C}$

[SOURCE: EN 322:1993, 4.2]

3.23**passive sensor**

sensor that does not need any electrical power supply to operate

3.24**proxy**

material or a specimen that is a substitute or a replacement for something else, under the assumption of identical behaviour of the material under investigation

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EN 16682:2017 (E)**3.25****relative humidity****RH**

ratio of the actual vapour pressure of the air to the saturation vapour pressure

Note 1 to entry: The RH is expressed in percent (%).

[SOURCE: EN 15757:2010, 3.9]

3.26**relative method****relative measurement**

measuring method whose readings cannot be expressed in terms of SI units and should be expressed in relation to something else, kept as a reference

Note 1 to entry: The scale depends on the specific choice of the reference; it can also be expressed as a fraction of a given value.

3.27**sample**

portion of material, ideally representative, removed from the cultural property for scientific investigation

[SOURCE: EN 16085:2012, 3.2]

3.28**temperature**

temperature read on a thermometer which is exposed to air in a position sheltered from direct solar radiation or other energy sources

Note 1 to entry: The temperature is expressed in degrees Celsius (°C).

[SOURCE: EN 15758:2010, 3.1]

3.29**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, 3.20]

3.30**vacuum drying**

drying method obtained by vacuum pumping to lower the atmospheric pressure to 4 ± 2 hPa in the drying chamber

3.31**vacuum gauge**

instrument for measuring gas or vapour pressures that are less than the prevailing atmospheric pressure

[SOURCE: ISO 3529-3:2014, 2.1.2]

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3.32**water content****WC**

amount of water in the material, as determined in accordance with the Karl Fisher titration specified in this European Standard; this method may include crystallization water

Note 1 to entry: The WC is expressed as a mass fraction in percent (%).

4 Symbols and abbreviations

EFD	Evanescant-Field Dielectrometry
EMC	Equilibrium Moisture Content
ESB	External Sealed Box
IAEA	International Atomic Energy Agency, Vienna
KF	Karl Fischer
KFT	Karl Fischer titration
C-KFT	coulometric KFT
V-KFT	volumetric KFT
MC	Moisture Content expressed on dry basis
MC _w	Moisture Content expressed on wet basis
NIR	Near Infrared
NIRS	Near Infrared Spectroscopy
NMR	Nuclear Magnetic Resonance
OV-KFT	Oven-vaporization KF titration
C-OV-KFT	coulometric oven-vaporization KF titration
V-OV-KFT	volumetric oven-vaporization KF titration
RH	Relative Humidity
SI units	International System of units
SRXTM	Synchrotron-based X-ray Tomographic Microscopy
TDR	Time-Domain Reflectometry
TGA	Thermogravimetric Analysis
VOC	volatile organic compounds
WC	Water content expressed on dry basis
WC _w	Water content expressed on wet basis
ϵ	dielectric constant
m_H	initial (moist) mass of the test sample
m_0	mass of the sample after drying
m_w	mass of water extracted from the sample