SLOVENSKI STANDARD
SIST EN 16782:2016

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Ohranjanje kulturne dediščine - Čiščenje poroznih anorganskih materialov - Tehnike laserskega čiščenja, ki se uporabljajo pri kulturni dediščini

Conservation of cultural heritage - Cleaning of porous inorganic materials - Laser cleaning techniques for cultural heritage

Erhaltung des kulturellen Erbes - Reinigung von porösen anorganischen Materialien - Laserstrahlreinigungsverfahren für kulturelles Erbe

Conservation du patrimoine culturel - Nettoyage des matériaux inorganiques poreux - Techniques de nettoyage au laser des biens culturels

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97.195	Umetniški in obrtniški izdelki. Kulturne dobrine in kulturna dediščina	Items of art and handicrafts. Cultural property and heritage

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EUROPEAN STANDARD
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English Version

Conservation of cultural heritage - Cleaning of porous inorganic materials - Laser cleaning techniques for cultural heritage

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Erhaltung des kulturellen Erbes - Reinigung von porösen anorganischen Materialien - Laserstrahlreinigungsverfahren für kulturelles Erbe

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Page

European foreword

This document (EN 16782:2016) 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of an identical text or by endorsement, at the latest by November 2016, and conflicting national standards shall be withdrawn at the latest by November 2016.

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Introduction

A cleaning method can be applied out if it follows the ethical code of conservation practice as stated in International Charters.

Laser cleaning consists in the removal of the unwanted surface materials from a substrate by using laser irradiation. The removal of unwanted substances on surfaces of artworks is done by photo-thermal processes and/or photomechanical processes, and/or photochemical processes.

Laser cleaning is generally characterized by a high precision and selectivity, which may allow the process to be stopped at a pre-determined level.

Laser cleaning requires very precise control to be selective and prevent surface damage. As with other cleaning systems, laser cleaning can only be performed by trained operators with sufficient knowledge of all relevant laser safety regulations and guidelines.

This standard specifies the requirements for the selection of laser cleaning methods and devices applicable to natural stone, ceramics and mortars (plasters, renders and stucco). When it is not possible to identify a safe working fluence (for example for certain stone lithologies or some painted artworks containing sensitive materials), laser cleaning is not suitable.

1 Scope

This European standard applies to porous inorganic materials constituting cultural heritage. It provides the fundamental requirements of the laser parameters and guidelines for the choice of the laser operational parameters, in order to optimize the cleaning procedure.

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

EN 16572:2015, *Conservation of cultural heritage — Glossary of technical terms concerning mortars for masonry, renders and plasters used in cultural heritage*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15898:2011, EN 16572:2015 and the following apply.

3.1
cleaning
removal of unwanted material from an object

Note 1 to entry: The criteria for something being "unwanted" can always be stated, e.g. potentially damaging, obscuring detail, unaesthetic, etc.

[SOURCE: EN 15898:2011, 3.5.3]

3.2
mortar
material traditionally composed of one or more (usually inorganic) binders, aggregates, water, possible additives and admixtures combined to form a paste used in masonry to provide for bedding, jointing and bonding, and for surface finishing (plastering and rendering) of masonry units, which subsequently sets to form a stiff material

[SOURCE: EN 16572:2015, 3.1.1]

3.3
plaster
coating composed of one or more mortar layers applied in one accomplishment sequence, used on internal masonry surface such as ceiling, walls, and partition

Note 1 to entry: Plaster is a traditional English term.

[SOURCE: EN 16572:2015, 3.2.5]

3.4
render
coating composed of one or more mortar layers applied in one accomplishment sequence, used on external masonry surfaces and which has protection function and surface finishing

Note 1 to entry: Render(ing) is a traditional English term.

[SOURCE: EN 16572:2015, 3.2.6]

3.5
stucco
mortars used for making decorative mouldings, architectural castings and other decorations on the facades and in the interiors of the buildings

[SOURCE: EN 16572:2015, 3.2.8]

3.6
laser
Light Amplification by Stimulated Emission of Radiation
radiation source that generates a coherent, monochromatic and very powerful beam of light in the range of ultraviolet, visible or infrared wavelengths

3.7
laser ablation
removal of material from an object induced by the laser radiation absorption, in the form of molecular radicals, vapours and particles of different sizes

3.8
photo thermal ablation
ablation process caused by heat generated by the laser radiation absorption

3.9
photo mechanical ablation
ablation process caused by mechanical stress and strains induced by the laser radiation absorption

3.10
photo chemical ablation
ablation process caused by chemical bond cleavages induced by the laser radiation absorption

3.11
light
radiation that is considered from the point of view of its ability to excite the visual system

Note 1 to entry: It corresponds to the so-called visible radiation in the range between 380 nm and 780 nm.

Note 2 to entry: In the field of conservation, this term sometimes extends the range outside the visible portion, including parts of the ultraviolet (UV) and near infrared (IR) regions.

[SOURCE: CIE S 017/E:2011]

3.12
infrared radiation
part of the electromagnetic spectrum with wavelength longer than those of the visible radiation, from about 780 nm to tens of micrometres

[SOURCE: CEN/TS 16163:2014, 3.18)]

3.13
ultraviolet radiation
part of the electromagnetic spectrum with wavelengths from 10 nm to 380 nm

[SOURCE: CEN/TS 16163:2014, 3.36]

3.14
irradiated area
spot
area of the object subject to the laser beam during one single shot, in cm^2

3.15
laser fluence
amount of energy divided by the irradiated area, in joules per square centimetre (J/cm^2)

Note 1 to entry: The energy density can be changed at the sample surface if lenses are placed in the path of the laser beam.

3.16
power density
power divided by the irradiated surface, in watt per square centimeter (W/cm^2)

3.17
laser continuous wave emission
CW emission
stationary emission of a radiation laser at a constant power, in which the interaction of the laser beam and a surface is largely thermal

3.18
average power for laser continuous wave emission
energy emitted by a laser in one second, in watts (W)

3.19
laser pulsed emission
mode of laser emission consisting of successive temporal pulses having a constant duration and characterized by an instantaneous power (see 3.16) much higher than the average power.

Note 1 to entry: In pulse mode, the interaction of the laser beam and a surface is commonly believed to be a combination of thermal and mechanical processes.

3.20
peak power
single pulse energy divided by the duration of the pulse, in watts (W)

3.21
average power for laser pulsed emission
result of multiplication of pulse energy by the repetition rate, in watts (W)

3.22
pulse duration
Full Width Half Maximum, or width at which the pulse energy/power is half that of the maximum energy/power

Note 1 to entry: The duration of a pulse from a laser is a key factor in determining how the light will interact with material. Pulse durations range from “ultra short” femto seconds (10^{-15} s) to “long pulse” micro seconds (10^{-6} s).

Note 2 to entry: This definition refers to how “pulse duration” is usually defined.

3.23
laser repetition rate
<pulsed laser> number of pulses per second, in hertz (Hz)

3.24
reflectance
ratio between the light intensity reflected by a surface and the incident light on the same surface, in percentage (%)

3.25
depth of optical penetration (into the material)
distance measured from the surface coincident with the reduction of the intensity of incident light radiation equivalent to 1/e and by means of absorption (e ~2,7)

3.26
Q-switched laser
laser generally having a pulse width in the range 5 to 30 ns, put to use by the technique of q-swithching that is used to produce a pulsed output laser beam, allowing the emission of pulses with extremely high peak power

3.27
free running laser
laser in which the emission lasts as long as the pumping process is sufficient to sustain lasting condition

Note 1 to entry: Typical pulse durations are in the range of µs-ms.

3.28
laser ablation fluence threshold
AF_{th}
lowest fluence that causes ablation of the material to be removed

3.29
laser damage fluence threshold
DF_{th}
lowest fluence that causes unwanted changes to the material to be preserved

4 Symbols and abbreviations

F_{L}	laser fluence
F_{th}	threshold fluence
AF_{th}	laser ablation fluence threshold

F_{th}(A)	threshold fluence at point A (beginning of ablation of layer A)
F_{th}(B)	threshold fluence at point B is the damage threshold fluence DF_{th}
DF_{th}	laser damage fluence thresold
F_{lim}	threshold fluence limit
CW	continuous wave
QS	Q-Switched
FR	free running
SFR	short free running
m_{abl}	amount of material removed for each laser pulse
$F_{th(sat)}$	threshold fluence corresponding to the saturation of the removal process

5 Key features of the laser system with respect to the cleaning of porous inorganic materials

5.1 General

The choice of the most appropriate laser system shall be carried out after the characterization of materials, their condition and after having established what shall be removed and what shall be preserved. A laser, emitting at a given wavelength, will only remove layers containing components able to absorb the energy at this specific wavelength. Where the possibility exists of undesirable dis-/coloration effects established methodologies that have been proven to reduce or overcome the issue shall be considered and tested (such as combination of wavelengths, longer or shorter pulse durations etc.). As a consequence, the choice is dependent on the nature of the layers to be removed, and on the wavelength of the laser. Pulse duration will influence the interaction mode (see Annex A).

5.2 Wavelength

The following parameters are influenced by the wavelength:

1) the optical absorption of the material involved in the laser cleaning. This parameter can be estimated by measurements of reflectance at the wavelength of the laser radiation (see Annexes B and F);

2) the penetration depth of the laser radiation in the material which shall be chosen in relation to the depth of the material to be removed;

3) the ablation processes in general.

5.3 Laser pulse duration

This parameter influences the physical processes that are causing the ablation and consequently the possible harmful effects such as thermal damages for the long pulses (hundreds of microseconds), or photo-mechanical damages for the short pulses (nanoseconds) (see Annex C).

5.4 Regime of pulsed emission

The use of a pulsed laser system is indicated where it is necessary to minimize heat buildup and the resulting thermal damage to the substrate.

The pulse may be applied in intervals measured in femto-seconds to a few hundreds of microseconds, usually between 5 and 25 ns (QS) and 100-200 µs (FR).