SLOVENSKI STANDARD
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Ohranjanje kulturne dediščine - Osvetljevanje razstav kulturne dediščine

Conservation of cultural property - Exhibition lighting of cultural property

Erhaltung des kulturellen Erbes - Beleuchtung von Ausstellungen des kulturellen Erbes

Conservation des biens culturels - Eclairage d'exposition des biens culturels

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Conservation of cultural property - Exhibition lighting of cultural property

Erhaltung des kulturellen Erbes - Beleuchtung von Ausstellungen des kulturellen Erbes

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Foreword

This document (prEN 16163:2010) has been prepared by Technical Committee CEN/TC 346 “Conservation of cultural property”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

Introduction

Lighting is needed for many specific functions in museums and other cultural heritage organisations, for example for research, conservation and permanent or temporary exhibition. This standard deals only with lighting for permanent and temporary exhibitions in museums and galleries and does not consider lighting in other cultural heritage contexts such us hypogeal sites.

Lighting is one of the most important factors enabling visitors to fully enjoy works of art and other cultural property. In fact, light is the key element for the links with our environment: humans need light and their need increases with ageing. On the other hand conservation consideration must be taken to care for the objects for future generations since light is an environmental factor, which is a threat to many objects. Alone or in combination with other environmental factors (temperature, humidity, pollution, etc.) light causes fading, discoloration and embrittlement to a wide range of materials. This damage is cumulative and irreversible: no conservation treatment can restore change of colour or loss in strength of materials damaged by light. Accordingly, the challenge of museum display lighting is to find an appropriate compromise between the requirements of the conservation and the needs of visitors and of a suitable exhibition design. As an integral part of an exhibition, display lighting contains both objective and subjective aspects:

— the conservation aspect – sensitivity of the object, spectral composition of the light source and total luminous exposure,

— the visual aspect – the impact of lighting on the visitor experience: lighting must give visitors a good view of presented objects, without glare, reflects or insufficient illumination,

— the exhibition design aspect – the lighting design must participate with the interpretation and be meaningful.

1 Scope

This document defines the procedures as well as the means to implement good lighting, with regard to the conservation policy, but still regarding the conditions of visibility and exhibition design. It aims at providing a tool for setting up a European common policy and a guide for help curators, conservators and project managers to give to the architects and designers a correct lighting program with a European reference.

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
annual light exposue
illuminance level multiplied by the time for which the object is exposed at that level. It is expressed in lux-hours per year (lxh/y). One year of museum display is approximately 3000 hours. See also total luminous exposure

3.2
blue wool scale
scale of light-fastness, which comprises eight categories of standard dyed wools. The first is the most responsive to light; the second is approximately half as responsive as the first; and so on to the eighth, which is the least responsive

3.3
colour rendering index (CRI)
measure of the degree to which the psychophysical colour of an object illuminated by the test source conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation

NOTE The general colour rendering index (Ra) is calculated on eight Munsell samples, all of which have low to moderate chromatic saturation. Theoretically, CRI spans between 100 (best conditions) and 0 (worst conditions). Usually for white sources CRI spans between 100 and 60.

3.4
colour temperature
temperature of a Planckian radiator whose radiation has the same chromaticity as that of given stimulus

NOTE The reason this measurement is called a "temperature" is because it was derived from a theoretical ideal object called a "black body radiator". When the radiator is heated, it changes from black to red to yellow to white to blue. The lower the Kelvin rating, the "warmer" or more yellow the light, while the higher the rating, the "cooler" or more blue the light. The unit is the Kelvin (K).

3.5
daylight
part of global solar radiation capable of causing a visual sensation. Daylight colour temperature can span from about 2500 K (at sunrise and sunset) to 20000 K (blue sky) and depends on day hour and season of the year

3.6
daylighting
lighting for which daylight is the light source. Formerly the term “natural light” was used, but “daylighting” is now in use in analogy with the term “electric lighting”

3.7
daylight factor
ratio of the illuminance at a point on a given plane due to the light received directly and indirectly from a sky of assumed or known luminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky. The contribution of direct sunlight to both illuminances is excluded

3.8
dosimeter
device or apparatus for total luminous exposure measurement during a given period of time

3.9
effective irradiance
results from weighting the irradiance with the spectral sensitivity at the different wavelengths

3.10
exhibition design
spatial interpretation of the curatorial purpose. It contains the design of showcases, colour setting, panels, sound and lighting

3.11
filter
any device that selects a more or less wide portion of the electromagnetic spectrum (coloured and neutral filters, conversion temperature blue (CTB) and conversion temperature orange (CTO) filters, anti-UV or anti-IR filters). Neutral-density filters decrease the transmitted light by a known amount without selecting any wavelength

3.12
illuminance
photometric quantity that corresponds to the radiometric quantity irradiance. Ratio between the luminous flux d Φ incident on an element of the surface containing the point, and the area d*A* of that element. It is measured in lux (lx)

3.13
illuminant
radiation with a relative spectral power distribution defined over the wavelength range that influences object colour perception. It is a mathematical function, which defines a specific spectral power distribution incident on the object. It cannot always be exactly realized with a source

3.14
infrared radiations (IR)
part of the electromagnetic radiation with wavelengths longer than those of the visible radiation, from about 780 nm to tens of micrometers

3.15
irradiance
radiometric quantity that is the ratio between the radiant flux d Φ_e incident on an element of the surface containing the point, and the area d*A* of that element. It is measured in watt per square meter W/m^2

3.16
light
light is the portion of the electromagnetic radiation to which the human eye is sensitive (*c.* 380 nm – 780 nm). In the field of conservation, this term extends the range outside the visible portion, including the ultraviolet (UV) and near infrared (IR) regions

3.17
lighting
art, devices or techniques used for illumination

3.18
light meter
apparatus for illuminance measurement

3.19
luminous flux
photometric quantity that corresponds to the radiometric quantity radiant flux. It is measured in lumen, lm

3.20
lux
lx. Unit of illuminance. Illuminance produced on a 1 m^2 surface by a luminous flux of 1 lumen uniformly distributed over that surface. 1 lx = 1 $lm.m^{-2}$

3.21
lux meter
see light meter

3.22
photometric quantities
quantities that are based on the perception of radiation by the human eye and are valid only for visible radiations

3.23
optical radiation
see light

3.24
radiant flux
radiometric quantity. It is the radiant energy transported per unit time into a region of space by the electromagnetic wave. It is measured in Watt, W

3.25
radiometric quantities
quantities that are based on purely objective physical measures

3.26
source
object that produces a radiant flux, visible (light) and/or not visible (e.g. UV, IR)

3.27
Spectral Reflectance Factor
characteristic of a material surface. It is the ratio of spectral reflected light by the object to spectral irradiance emitted by the illuminating source

3.28
spectral sensitivity
describes the wavelength dependence of the material properties as the result of a radiant exposure under otherwise equivalent conditions of exposure. It is dimensionless and assumes values between 0 and 1

3.29
total luminous exposure
photometric quantity. It is the sum of the illuminance level over a given period of time. It is measured in lux hours [lxh]

3.30
ultraviolet radiation (UV)
part of the electromagnetic radiations with wavelengths shorter than those of the visible radiation, from 10 nm to 380 nm

4 Damage to cultural property caused by optical radiations

4.1 Mechanisms of damage

Light may damage vulnerable objects with two mechanisms:

— photochemical action,

— radiant heating effect.

Moreover, optical radiations, particularly in combination with high relative humidity, can favour the growth of biological organisms, such as mould.

4.1.1 Photochemical action of optical radiation

The absorption of light by a molecule or an ion can induce chemical changes, thus changing the mechanical properties and colour of the material, altering the object in an irreversible way. The activation energy for the change is supplied by the absorbed light, which brings the physical system to an excited state. The start does not depend on the surrounding environment, but the subsequent chemical processes can be affected by environmental factors such as temperature, relative humidity and possible presence of photo sensitizers.

4.1.2 Radiant heating effect of optical radiation

The energy supplied by light raises the temperature of the surface on which light impinges, depending on the amount of light that is absorbed, heat diffusivity within the object, and convective exchanges. Apart from thermal stress induced on the artefact, and desiccation, which can be caused by a decrease in local relative humidity due to the temperature rise, the higher temperature level accelerates chemical reactions and photochemical processes.

4.2 Sensitivity and classification for cultural property

The table below lists materials in four categories according to their sensitivity to light.

Table 1 — Classification of sensitive cultural property from CIE 157:2004

Category	Description
1. No sensitivity	The object is entirely composed of materials that are **insensitive to light**. Examples; most metals, stone, most glass, genuine ceramic, enamel, most minerals.
2. Low sensitivity	The object includes durable materials that are **slightly light responsive**. Examples; oil and tempera painting, fresco, undyed leather and wood, horn, bone, ivory, lacquer, some plastics.
3. Medium sensitivity	The object includes fugitive materials that are **moderately light responsive**. Examples; most textiles, watercolours, pastels, prints and drawings, manuscripts, miniatures, paintings in distemper media, wallpaper, and most natural history objects, including botanical specimens, fur and feathers.
4. High sensitivity	The object includes **highly light responsive** materials. Examples; silk, colorants known to be highly fugitive, graphic art and photographic documents.

4.3 Total luminous exposure

The photochemical effect is closely related to the cumulative radiation received by the object. According to the reciprocity law, the net photochemical effect is the result of the total exposure which an object receives. In other words, it is the total energy hitting the object in its lifetime, which matters:

Total luminous exposure = illuminance x time expressed as lx hours/year (photometric units)

The following table gives the recommended values of maximum total luminous exposure for the different classes of light sensitive objects.

Table 2 — Total luminous exposure for different classes of light sensitive object interpreted from CIE 157:2004

Material classification	Blue wool scale	Total luminous exposure
1. Insensitive	-	no limit (for conservation)
2. Low sensitivity	7 & 8	600 000 lxh/y
3. Medium sensitivity	4, 5 & 6	150 000 lxh/y
4. High sensitivity	1, 2 & 3	15 000 lxh/y

When more classes of materials are simultaneously present, the limit to be considered corresponds to the most protected class. It should be taken into account that other physical or chemical factors (relative humidity, temperature, pollutants) can enhance the effects of light, so that in adverse environmental conditions the reported limits are mandatory.

5 Optical radiations measurement

5.1 Visible radiation measurement

The illuminance shall be measured with lux-meters sensitive in the 380 - 760 nm range. Several types of devices are available to measure indoor light levels. The measuring range shall be from 0.1 lx to 10^6 lx.

When measuring light, the lux-meter should be placed as close as possible to the most light exposed part of the object’s surface. The sensor surface is oriented parallel to the object. If the object is not flat, the sensor should be parallel to the most exposed or vulnerable surface.

The effective illuminance on a surface depends on its orientation to the light source, being proportional to the cosine of the angle of incidence of light on the surface (Cosine law). When light comes from different sources, or when the surface of the object is not perpendicular to the incoming light, measurements should be performed with lux-meters having the cosine correction function, so as to provide a correct evaluation of actual illuminance on the target.

If the room is lit with artificial light only, one run of measurements is sufficient. Special lighting during cleaning works and similar must also be measured and taken account of in the total luminous exposure.

If the room is lit with natural light, one set of measurements is not enough, because light levels change with the weather, time of day and season. It is essential to position the lux-meter exactly and always in the same sampling points, in order to avoid distortion of the information. The monitoring should be done during one year to take into account the daily and seasonal variations.

Many devices can supply instantaneous illuminance as well as total luminous exposure by integrating the data over time, so called data loggers. Moreover, a semi-quantitative evaluation of the total luminous exposure can be obtained by disposable sensors such as Blue Wool Standard or similar dosimeters, which fade or change their colour when exposed to light. These allow a user-friendly and satisfactory indication of the light dose received, expressed in terms of lxh/y.

Alternatively, it is possible to use the concept of prevision of the quantity of light over one year or over the duration of the exhibition. It can be evaluated by the method of the "daylight factor". An annual illuminance is available by the weather agency of each country. In order to predict the quantity of light indoors, it is necessary to measure, at the same time, illumination both outdoors and indoors.

5.2 UV measurement

Ultraviolet (UV) radiation is more energetic than visible light. It cannot be perceived by the human eye and is therefore not needed for our vision. As it can cause objects to deteriorate, it must be eliminated or, at least, reduced at the lowest possible level. There are two ways to measure, or more precisely, to prove the presence of UV.

The first method is using a UV-meter, a device which gives quantitative values in microwatt per square centimetre (µw/cm^2). Different manufacturers produce their own UV sensors. The result is a multitude of UV sensors showing different curves. For UV measurements, the only choice is 365 nm at the maximum of the sensibility curve.

The second method is using the “UV monitor” especially developed for museum use. It measures the proportion of UV radiation present in the light. It is measured in microwatts per lumen (µw/lm) which is not part of the international system of measurements.

To verify the presence of UV radiation with an ultraviolet meter, two measurements are necessary. The first with a UV filter in front of the sensor, the second without. If the difference is significant (i.e. not less than 50%), the light source contains UV and shall be eliminated.

With the special “UV monitor” for museum use, the elimination of the UV source is necessary if the value exceeds 75 µw/lm (value measuring on incandescent light source).

The elimination of UV for vulnerable objects and collections will have effect only if at the same time visible light is controlled.

6 Visual ergonomics rules for exhibition lighting

6.1 Quality of light

The choice of a source for museum lighting should provide a good colour rendering. Usually the CIE colour rendering index (CRI) is adopted to classify light sources. The best sources are daylight and incandescent lamps with a CRI close to 100. It is possible to use luminescence lamps, specially fluorescent lamps with 95-98 CRI. If the colour of the object is not an important factor it is possible to use lamps with 80-85 CRI. In general, the spectral irradiance of the source should carry all wavelengths that are reflected from the object with an intensity as wide as that perceived by the human eye. The colour temperature of the source is another factor that influences object vision. Generally, low level of illumination request low colour temperature, about 3000 K and high level of illumination request high colour temperature.

6.2 Illumination level

To see displayed objects properly, not only an excellent quality of light is required, but also a certain level of illumination. The necessary level is subjective and related to the age of the observer, because the performance of the human vision diminishes with increasing age. However, it also depends on the background illumination level (contrast), i.e. a clear detail appears more luminous on a dark background compared to a